THE GENERAL SCIENCE OF NATURE

Vincent Edward Smith

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To VIRGINIA

"Whose art is always an imitation of nature" (Chapter VII, p. 137)

PREFACE

If you pursue the various sciences according to the order of learning proposed by St. Thomas Aquinas, the science of nature will be learned first, right after the preparation for science in the liberal arts of logic and mathematics;[1] and the first part of the science of nature concerns the type of question raised by Aristotle in his *Physics*.[2] To any follower of Aristotle and Aquinas, metaphysics or natural theology will always be the most important of the sciences which unaided reason can achieve; but according to St. Thomas' own order of learning, the science of nature, as found in the *Physics,* will always be the most fundamental. Presupposed by metaphysics, this kind of scientific knowledge is presupposed also by science in the modern sense of the term.

The *Physics* of Aristotle handles general questions,[3] logically prior to all special investigations and answered by none of them. That is why its contents can be called the general science of nature. Its conclusions do not depend upon those specialized experiences which we call deliberate experiment; nor does their nature allow them to be formulated in the exact language of mathematics. Since they were independent of the specialized techniques of modern research, Aristotle's instruments for constructing a general science of nature were no better or worse than our own. To begin this general science requires only a knowledge of logic and our common experience of change. That is why the principles discovered in Aristotle's *Physics* remain perenially true, even though other parts of his natural science have long since been overthrown.

To set forth for the modern student the general science of nature as inspired by Aristotle's *Physics* is the aim of this book. Thinkers as different from each other as Aristotle and Einstein, Aquinas and Bergson, Mach and Maritain, Whitehead and Philipp Frank, Eddington and Dewey, all admit the need for a serious study of the presuppositions of the sciences, and in a sense this book might even be called "the foundations of science."

Tire book follows the well-defined order in the *Physics.* Since Aristotle discusses the foundations of physical knowledge in the first two books of the *Physics,* and since contemporary difficulties with this problem are so marked, the first twelve chapters are given over to it. With Chapter XIII begins the formal treatment of the science of nature as such. For a teacher who wishes to gain time, parts of the book marked with an

asterisk (*) may be omitted and/or assigned for reading outside of class. There are, no doubt, other parts of the book that teachers may wish to pass over.

In order to simplify presentation, controversies have for the most part been left aside; they are introduced only to relate the topics treated to the situation today. Special attention has been paid to the logical and ontological relations between science and philosophy.

In current idiom, the word philosophy is almost equivocal. Unlike any other department of most modern colleges and universities, our philosophy departments teach not only one but four distinct sciences[4] and, in addition, the history of philosophy. In order to designate the contents of this book, I have preferred St. Thomas' term "natural science" (scientia naturalis) : as he writes, "the work of the *Physics,* whose exposition we intend, is the first book in natural science. . . ."[5] I have preferred to speak of the general vs. special sciences of nature rather than the philosophy of nature vs. modern science.

Because of the clarifications and additions he makes to Aristotle, St. Thomas in his *Commentary on the Physics* has been preferred as a source to Aristotle himself. The bibliographical apparatus has been explained in a note preceding the index.

Special thanks are due to my wife, Virginia, for her innumerable aids. The manuscript was read in its entirety by the Rev. Dr. Benedict Ashley, O.P., of the Albertus Magnus Lyceum for Natural Science. Father Ashley's criticism was of immense assistance in both the additions and subtractions it suggested. Other members of the Lyceum staff at the Dominican House of Studies, River Forest, Ill., especially the director of the Lyceum, the Rev. Dr. William H. Kane, O.P., made many valuable suggestions. Gratitude must be expressed to Mr. William E. May of The Bruce Publishing Company, for services above and beyond the call of duty. I am also grateful to my former students at the University of Notre Dame, who were taught from the manuscript of this book, and to Mr. Thomas Lopina for his typing services.

-V. E. S.

NOTES TO PREFACE

1. The *Book* of *Causes,* I; Commentary on *the Ethics,* Bk. VI, les. 7; Commentary on the *Trinity,* q. 5, a. 1, replies 1, 9.
2. Commentary on the Physics, Bk. I, les. 1, 1.
3. *Ibid.,* Bk. I, les. 1, 4.
4. Logic; the philosophy of nature, including philosophical psychology; ethics, general and special; and metaphysics, which includes epistemology and natural theology.
5. Commentary on the *Physics,* Bk. I, les. 1, 1.

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THE GENERAL SCIENCE OF NATURE

CHAPTER I

SCIENCE AND ITS DIVISIONS

I. INTRODUCTION

a. *Importance of Logic*

There is a saying that a small error at the beginning of any study becomes a large one by the end.[1] Today there is perhaps no more important illustration of this maxim than in our study of the physical, natural world. Does it make any difference how or where we begin a science of nature? Where should we commence the scientific study of our universe? Do we begin with measurements and with controlled experimentation? Should a unified science of nature first chart the course of the stars and then consider things on earth? Or would it be more logical, in the quest of a unified view of our universe, to start with the mathematics of falling bodies? From one point of view, a case might be made to expound the atomic theory as the opening chapter of a book on nature; but, from another angle, mass and energy seem more basic and hence more logical starting points in a science of material things. Is there perhaps any knowledge of matter and its motions which is presupposed to what we usually study in physics, chemistry, and biology? An error made at the beginning of our study of nature will spread to considerable size by the time our study is fairly advanced. If we do not begin at the proper starting point, everything is likely to be out of perspective.

In order to organize our knowledge of any subject into scientific form, it is first necessary to learn logic.[2] Logic teaches us how to make a critical ordering of our acts of reasoning and thus to proceed in an easier, more organized, and correct fashion in the making of science.[3] A review of logic will enable us to know how to avoid in our science of nature the little error in the beginning which will grow greater as time goes by.

b. *Vague Modern Meanings of Science*

In current usage, the term science has a meaning quite loose and obscure. Organized knowledge of any kind was considered as scientific by Herbert Spencer,[4] a British sociologist at the beginning of our century, and something of this definition is in the air around us today. Almost every subject can invoke this definition to claim a scientific character for itself — psychology, history, comparative literature, anthropology, linguistics, even hotel management and coaching an athletic team. Sometimes the term science is reserved only for those subjects that measure and make deliberate experiment, and in this light the most perfect of all the sciences is often considered to be modern physics. Of this subject, Max Planck has written:

> The material with which theoretical physics operates is measurements, and mathematics is the chief tool with which this material is worked. All physical ideas depend upon measurements more or less exactly carried out, and each physical definition, each physical law, possesses a more definite significance the nearer it can be brought into accord with the results of measurements.[6]

Science is often portrayed as a knowledge so exact that it is mathematical in form. Tobias Dantzig has written, "Read your instruments and obey mathematics; for this is the whole duty of the scientist."[6]

The frequent restriction of the term science to mean exact and metrical knowledge has a history dating back at least as far as Isaac Newton. Like Galileo, who measured the effects of gravity but hesitated to investigate the nature of gravity itself, Newton, at least according to his own intentions, confined his science of nature to mathematical laws concerning "properties." In his words,

> I have not been able to discover the cause of those properties of gravity for phenomena, and I frame no hypotheses; for whatever is not deduced from the phenomena is to be called an hypothesis.[7]

Such apparent mathematical descriptions of mere "properties" without pushing on to "causes" have led to the view which strongly emphasizes that correlations and measurements are the very essence of science. This view, which may be roughly classified as positivism, denies that science must concern "the cause of those properties" that are measured and correlated. As a result, science is frequently applied today only to knowledge obtained by measurement and controlled experimentation, activities that give "positive" results.

However, if Spencer's definition of science is too broad, the identification of science with measurement is too narrow. Our present purpose

will be served if we simply agree that science in a modern sense of the term is the kind of knowledge we call today physics, chemistry, and biology.

II. THE ARISTOTELIAN NOTION OF SCIENCE

a. Two *Definitions From Logic*

In the history of Western thought, the term science has another and older meaning. Science in this older sense is a certain knowledge of things in terms of proper causes or reasons or principles,[8] and demonstration is a syllogism productive of such knowledge.[9] Both of these definitions stem from Aristotle.

As far as our records go, Aristotle[10] was the first thinker to construct a universal scientific knowledge about nature. Both his logic and bis science of nature were in the main adopted by St. Thomas Aquinas[11] in his great thirteenth-century summation of learning. The logic of Aristotle and the approach to nature that such a logic requires form the broad plan of the present book. Aristotle and St. Thomas will be our guides as we go through the following pages.

Yet our purpose in consulting these teachers is not "to know what men have thought but how stands the truth of things,"[12] and teachers like these are eminently equipped to help us to the truth of things. As a student, if he wished to learn physics, would like to learn it from a man like Planck or, if he wished to learn mathematics, would seek out a master like Dantzig, so in the effort to learn the subject matter of this book it is prudent to seek out the help of great teachers like Aristotle and Aquinas.

The definition of science which Aristotle proposed began to widen in the seventeenth century when Galileo in physics[13] and Francis Bacon in logic[14] gave impetus to the modern notion of science as a knowledge gained by means of deliberate experimentation and measurement. On hearing the word science, the twentieth-century boy or girl almost invariably thinks of its modern meaning. From previous studies as well as from media like newspapers and television, the college student has come to think of science as having to do only with measurements of matter, with controlled experimentation, and with the invention of hypotheses and theories to account for experimental results.[15] To adjust one's mind to the other and older usage of the term science may be difficult. There might be ground to. argue that in the interest of clarity what Aristotle

called science be termed philosophy of nature[16] and that the word science be used only where and when its modern meaning is intended.

But there are stronger reasons, to be stated later, for continuing to call Aristotle's approach to nature scientific. There are even reasons to restrict the term science entirely to its Aristotelian meaning, at least at the beginning of our discussions. By making such a restriction, and by concentrating on science in Aristotle's logic, it will be possible later on to reach an horizon within which the ancient and modern uses of the term science can be closely related and even reconciled. For the moment, in the interests of clarity and simplicity, it will be prudent to dismiss temporarily any preconceptions about the common but perhaps confusing use of the terms science and scientific method and to think of science only as a certain knowledge of things in terms of causes and reasons and principles and to view demonstration as a syllogism which produces scientific knowledge. When perfected, science is knowledge through proper causes.

b. *How Aristotle's Definitions of Science and Demonstration Are Related to Each Other*

These two Aristotelian definitions are equivalent to each other. In order to show this, it is only necessary to review from the study of logic the nature of discourse or of the syllogism and to recall also the peculiar character of that kind of syllogism which is called demonstration.

A syllogism is a logical structure in which two terms are connected together in the conclusion because they have been connected in the premises with a common third term.[17]† Let us go at once to an easy example:

> Whatever is spiritual is indestructible.
> The human soul is spiritual.
> Therefore, the human soul is indestructible.

Here the two terms, the human soul and its character of being indestructible, are identified with each other because in the premises they have been identified with a common middle term. In all syllogisms of this kind, the middle term represents the cause or reason or principle for

* To gain time, teachers may omit and/or assign for reading outside class the sections of the book marked with an asterisk.

† Reference is being made here only to the categorical syllogism and indeed only to cases where both premises are affirmative. These restrictions are made only to economize our review of logic.

connecting the major term with the minor in the conclusion. The cause or reason why the human soul is indestructible is that it is spiritual.

There are, as we know from logic, four kinds of discourse: the demonstrative, the dialectical, the rhetorical, and the literary syllogism.[18] They differ from each other in the character of their middle term. In demonstration alone is the middle term certain; for in this case alone is there certitude concerning the causality involved. In a dialectical syllogism, for instance, the middle or causal term is tentative and the conclusion is more or less provable but not fully proved.[19] An example is in order here:

> Whatever astronomical theory is mathematically simple is the true theory of heavenly movements.
> The heliocentric theory is mathematically simple.
> Therefore, the heliocentric theory is the true theory of heavenly movements.

This is the substance of the argument by Copernicus[20] in favor of his own theory of astronomy as against the very complicated Ptolemaic theory. Admittedly the simplicity of the Copernican theory is a strong reason for favoring it when compared to the geocentric position. But such a middle or causal term alone is not enough to establish the heliocentric theory in a certain and necessary way; simple explanations of facts turn out often to be in error.[21] The syllogism in our example can therefore claim no more than a dialectical or provable status.

Demonstration, then, is a syllogism in which the causal knowledge or middle term is certain. Put into other form, knowledge resulting from demonstration is always a certain knowledge in terms of causes, precisely what Aristotle called science. Our two definitions — one of science and the other of demonstration — have turned out to be different ways of expressing the same thing.

e. *The Perfection of Science*

Anyone who has attained a certain and causal knowledge concerning a given subject or anyone who has made a demonstration has achieved a scientific knowledge of the subject in question. Such knowledge, however, becomes more perfect in proportion as it is made more precise. One person has a better possession of geometry than another when he knows more than the other about the subject matter. The more perfect geometrician has not stopped at only a vague and general knowledge about, say, triangles but is able to demonstrate more of the properties

of triangles; he has a more detailed and precise knowledge of them. The good theologian knows more about his subject than does a theologian less competent in the science. Science becomes perfect in proportion as the mind attains certain knowledge of the proper causes of things. In knowing proper, as opposed to common, causes, the mind knows how one thing differs from another and hence has a better grasp of the things falling under its science. The good scientist is not content with the common and rather imprecise notions which characterize a less perfect knowledge of the natural world. He is always eager to learn more and more about his subject matter. Hence, although it is permissible to define science as a certain knowledge in terms of causes, science at its best is a certain knowledge in terms of proper causes.[22] To have certain knowledge of causes, even when we know them only on a general level, is enough to constitute scientific knowledge. But it is science in only an imperfect form. In its most perfect form, science is a certain knowledge in terms of the proper causes of things, even though such knowledge is often exceedingly difficult to attain. By the same token, those demonstrations which have a middle term that represents the proper causes of a subject under consideration give us a more perfect scientific knowledge. A middle term that represents a proper cause of a subject is a "commensurate universal" of that subject; i.e., it is appropriate to, and coextensive with, the subject in question.

d. *Kinds of Demonstration*

Although there are a number of important divisions of demonstration, our present purposes will be served by distinguishing between the causal (demonstratio propter quid) and factual (demonstratio quia) demonstrations.[23] In the first, the middle term (at least in part) is the real definition of the subject and, as such, provides the real reason or cause why the attribute belongs to the subject in question. Thus, being spiritual in our example of demonstration is the real cause or reason why the human soul is indestructible. In factual demonstration, the middle term usually represents the cause or reason why we know that the attribute belongs to the subject in question; it does not represent the proper cause in reality itself why this is so. Consider the following demonstration:

> Whatever is capable of acting independently of matter is spiritual.
> The human soul is capable of acting independently of matter.
> Therefore, the human soul is spiritual.

Here the ability to act independently of matter is not the cause for the spirituality of the soul, but rather the cause of our knowing the spirituality of the soul. In the causal demonstration, the middle term represents the real causes of things, whereas in factual demonstration, the middle term ordinarily represents the causes of our knowledge.[24] In general, the causal demonstration may be regarded as going from cause to effect and the factual demonstration from effect to cause. Most of the fundamental demonstrations found in this book are of the factual type.[25]

III. THE CHARACTER OF FIRST PRINCIPLES

a. *The Notion of First Principles*

In exploring the conditions for the certitude of scientific knowledge, we must always remember that the middle term of a demonstrative syllogism represents a certain and necessary cause or principle. Now a principle is that from which anything flows in any manner whatsoever.[26] It comes from a Latin word (principium) that means "beginning," and it would not be a bad definition to call the principle of anything that from which the thing begins. A point is a beginning or principle of a line. A parent is a principle of a child. God the Father is the principle of God the Son. A principle, then, is a source or starting point. It implies a process and an order within that process;[27] wherever there is order there is at least one principle.

A principle is not the same as a cause.[28] It may be a cause, as a parent is a cause of a child. But there are also principles which are not causes, like the point on a line or like God the Father, who is the principle of the Son but not His cause. Principle implies orderly origin; but it does not imply dependence. A cause, on the other hand, necessarily involves dependence. A cause is indeed a principle, but a principle from which anything proceeds with dependence. It is that on which a thing (the effect) depends in being or in coming-to-be.[29] Thus, every cause is a principle but not every principle is a cause. For the purposes of this book, however, the distinction between cause and principle is not always of importance, and the terms will be frequently used interchangeably. To say that the middle term of a syllogism represents a cause is to say that it expresses a principle, and vice versa.[30] Finally, principle will be considered in the following pages as a "reality" like a cause and not as merely a logical entity, e.g., a premise in a demonstration.

The characteristic of the demonstrative syllogism is that the middle term causes certitude, and, to achieve certitude, the true scientist (in Aristotle's sense of the word) must begin not with any principles whatsoever but with first principles. In order to explain this, it will be instructive to define and to illustrate first principles and then to defend the proposition that without first principles there is no science (again taking science in Aristotle's sense).

First principles have two characteristics: Everything in the order under consideration is derived from them and they are underived within the order in question.[31] In other words they are (1) the ultimate sources for everything in the order under consideration, and (2) they are themselves underived or presuppositionless.

b. *First Principles as Sources*

A unit is the first principle of arithmetic.[32] From it, everything in arithmetic is derived. To be sure of our equation, $2 + 1 = 3$, we have to analyze 2 into the units it contains. Should anyone challenge our equation, we would resolve the 2 into its two units and show that the additional unit in the 1 makes our answer to come out 3; we are proving our point by showing that there are three units in our sum. Once we have the habit of correctly solving problems in arithmetic, we would never have to check such a simple equation as $2 + 1 = 3$, and no one past the first grade would challenge us to do so. Knowledge of the unit, consequently, is only implicit in most of our mathematical knowledge; but it must be made explicit at least at the beginning of the science of arithmetic; and it remains as an implicit condition and check point thereafter. It is the source, hence principle, of all our scientific or certain knowledge in the arithmetical order and constitutes the ultimate basis for all the certitude achieved in this order.

Within the family of subjects we already know, grammar has for its first principles the noun and the verb; geometry, the point and the line; theology, the articles of faith. From the unit everything in arithmetic is derived; the noun and the verb are the source of all grammar; the point and the line are the starting points of geometry. A first principle is the source of everything in the order under consideration, and if there is any scientific knowledge of nature (according to Aristotle's notion of science), first principles must be found in the physical world. Whether there are such principles will be a crucial question in Chapter III of this book.

c. *First Principles as Underived*

The second characteristic of a first principle is that it is underived within the order under consideration. Thus the unit is not derived within arithmetic, nor the noun and the verb within grammar, nor the point and the line within geometry.

As a principle of number, the unit for instance is no mere sum of fractions like ½ + ½. To understand the numerator 1 and denominator 2 in each of the foregoing fractions an understanding of the unit is required, and the case would be similar if the ½'s themselves were broken down into still smaller fractions ad infinitum. It makes sense to ask: "How many is two?" Such a question can be answered in the science of arithmetic. But to ask the same question about the principle of number: "How many are a unit?" is meaningless.

In a similar way, the grammarian cannot speak of the noun and the verb without using them; if only for this reason it can be seen that these two principles are underived in grammar. Finally, the articles of faith are the starting points of a theologian, underived in his science but revealed as the basis for all his considerations.

IV. SCIENCE AND FIRST PRINCIPLES

a. *The Need for First Principles*

With this brief background of what first principles are and how they are relevant to sciences we already know to some extent, it can now be asked how the notion of a first principle relates to the definition of science as a certain knowledge in terms of causes. By way of answering such a question, it has already been hinted that first principles are necessary for the certitude of a science. A demonstration may obtain its premises from other demonstrations, but in the last analysis a science must rest on principles that are indemonstrable because they are evident in themselves.

Such a verdict does not mean that first principles are presented to us in a clear and distinct way and without any analysis on our part. What self-evidence means[33] and how the mind comes into contact with self-evident principles are questions that will have to be postponed until we begin our quest, in the next chapter, for the first principles of nature. It is important here only to note that if first principles in any order are the source of all our knowledge in that order, any attempt to demon-

strate them in the order under consideration would have to apply them and beg the question. Any attempt to derive the unit by arithmetical demonstration would have to use the unit. To say that the unit is underived in arithmetic is to affirm that it is not demonstrated in arithmetic, and in a similar way none of the sciences can demonstrate what they themselves must always employ whenever they make any demonstrations.

First principles assure the certitude of scientific knowledge,[34] because in the study of any subject like number or the universe or revealed truth they give the mind some absolute and unconditioned starting point; and a small error in our starting point will be a large one later on. If the student of arithmetic did not begin his science with reference to the unit but chose instead to begin with some derived operation like $7 + 5 = 12$, he could never be certain of his conclusions, he could never check them, he could never defend them against doubt and denial. The checking of any equation in arithmetic requires, it was observed, an analysis of the expression that would eventually bring us to the number of units it contains. A theologian, careful to preserve the truths of his conclusions, is always returning to his sources — the Bible and tradition.

A traveler going to Chicago but not knowing his point of departure could reach Chicago only by the merest accident; in reading a map to find out how to reach a destination we have to know where we are. Like a journey, science involves a series of parts that are ordered. Science is an order in our knowledge of a subject. Since any order requires a principle, a permanent and necessary order, like certain knowledge, requires a permanent and necessary principle to certify it.[35]

b. "Science" *Without First Principles*

Imagine a student in quest of certain knowledge through causes and beginning the quest not with first principles but with principles that are somehow derived and relative. Since these secondary principles depend upon primary and ultimate ones which our imaginary student leaves unexplored, it is possible that the conclusions he draws from these secondary principles will demand some revision in the light of the unanalyzed first principles. Since first principles govern the entire realm investigated in a scientific study, any conclusions based only on secondary principles may be upset when first principles are later discovered and applied to the secondary ones. Nothing short of first principles can assure certitude in science.

To begin the quest for certitude by considering the derivative and secondary' — like 7 + 5 = 12 in arithmetic or the preposition in grammar — is like building a house without bothering to investigate whether the soil is hard or soft or even made of quicksand. To judge a man by his color or height once again gives priority to what is secondary; what is primary is his rational nature. If we judge the physical world without distinguishing the secondary from the truly primary, a blurred picture of the physical world will be developed. This has happened to a certain extent since Galileo and Bacon promoted science in the modern sense of the term at a time when science in the Aristotelian sense was losing its hold. The facts established by modern physics, chemistry, and biology may, like the color of hair and the height of people, be well-established truth; and theories, like those involving the atom and the evolution of living things, may well rank among the greatest triumphs of the human spirit. No one could quarrel with a single fact of modern science nor should he reject a single theory unless he can supply a more satisfactory one. Nevertheless modern discoveries about the material world, true as they may be in other respects, have often been misinterpreted when they have not been linked to the first principles in the general science of nature.

Much more of this important problem raised by science, in the modern sense of the term, will be met in ensuing chapters. This chapter has been laying the groundwork for our own solution; and, for a reason that will be apparent later, science in the Aristotelian sense is being explored first. Since such a science is certain knowledge in terms of causes, it needs principles to be causal knowledge and first principles to be certain knowledge. Whether there are such principles in the material world and how we know them must be left to Chapter III. Our concern so far has been only with the nature of science in the Aristotelian sense.

V. PRINCIPLES FOR DIVIDING SCIENCES

a. *The Notion of an Object*

So far the nature of a science has been sketched in a manner adequate at least for an introductory book. Our second project in this chapter is to differentiate the various sciences from each other. Sciences differ from each other according to their objects or their subjects. In an elementary discussion, the object and subject of a science will be used to mean the

same thing.[36] Let us consider science first in relation to its object and postpone until later any reference to the subject of a science.

If sciences, in the Aristotelian sense of the term, are divided by their objects, it is only proper to approach the division of scientific knowledge by asking in the first place what we mean by the word object. If we track the word itself to its Latin origin, object (ob-jectum) is that which is thrown against something else — a kind of obstacle that must be overcome.

All vital powers, nutrition, knowledge, and appetite deal with an object, that which is "thrown against" them and to which they in some way respond in a passive or active way. An object, in this meaning, is that which primarily and essentially confronts any vital power.[37] The colored, for instance, is the object of the power of sight; the hard or the soft is the object of the power of touch; the good is the object of the human will; food, of nutrition; and so on. In each case, the object specifies the power in question, entering into the very definition or species of that power and distinguishing it from other powers in a living thing. Sight cannot be defined except by reference to the colored. The primary difference between sight and hearing, for example, is that the one is the power of apprehending the colored and the other is the power to apprehend the sounding.[í] All other differences, such as structural differences in organs however important, are secondary, and a blind and deaf man could know them without ever knowing what it is to see or hear. The primary specification of knowing powers is by the object with which each is concerned — that which is "thrown against" the power in question. Since the object enters into the definition of the power, the object is said to specify, i.e., to give the species to, the power.

There is a difference between an object and a thing. Powers, like the powers of knowing in a man or in an animal, are not differentiated from each other by the things they concern. There is a very great difference as things between the gray (if it is smoke) and the red (if it is an apple); but both belong to the object of the same power, namely sight. There is very little chemical difference as things between what affects our taste and what affects our smell; but there is a great difference in object that is involved. An object is that which primarily and essentially confronts a vital power.

[í] In order to stress that the science of nature is concerned with concrete things rather than with mental abstractions, it is necessary to speak of the colored and the sounding, rather than of color and sound. Similar terms, admittedly awkward in English, will likewise be necessary to express concepts needed for the basic science of nature.

Science is a possession of that power which we call the human intellect, and just as sight differs from hearing primarily because it has a different object than does hearing, so one science differs from another because of differences in objects. To use a previous expression, sciences are specified or defined by their several objects.

There are two conditions which will enable us to make our first approach to the various objects of the various sciences.[38] One condition is on the part of the object itself, and the other is on the part of our mode of apprehending it. Either of these conditions taken alone would be sufficient to make our first and most general division of scientific knowledge, but both of them will be briefly explained so that a reader wishing to cover the matter quickly may concentrate on the one that seems easier.

b. *Different Conditions of Objects*

The first condition is on the part of the object itself.[39] If science is to enjoy the certitude which Aristotle's definition claims, the object of any science must be immobile. Tire reason is that certitude is achieved only where the object has a necessary character, i.e., it cannot be other than it is. If it could, we would never be certain that it is what it is. 2 + 2 = 4 is necessary on the part of the object because the truth that it expresses cannot be otherwise; 2 + 2 is always equal to 4. Hence we can be certain of it. Wherever there is motion, taking motion in a sense wide enough to include any type of change, there is some opposition to necessity. If necessity is characteristic of a thing or a truth that cannot be other than it is, it is a plain fact that a thing in motion is always in a state of otherness. A billiard ball moving across a table is always "in" another position from the one it "just occupied." A thing in motion is always other than it was simply because it is constantly changing. If science is to claim certitude, then the object of such knowledge must be conceived apart from motion. It must be immobilized. There will be as many different basic kinds of scientific knowledge as there are different ways of conceiving things by immobilizing them in some way.

c. *Different Conditions of Apprehending*

A second condition m regard to the object of science concerns our mode of apprehending that object.[40] As the work of the spiritual or immaterial intellect of man, science can exist in us only in an immaterial

manner. Hence the object of science must be immaterialized. In the physical world outside the mind, things have a material mode of existence. To become an object of scientific knowledge, they must be immaterialized. And there will be as many basically different kinds of scientific knowledge as there are different levels of immaterializing things in our concepts.

d. *Summary of Principles to Divide Sciences*

Immobility is required on the part of the object of science; immateriality is required on the part of the knowing power in which science exists. The process whereby the mobile and material world is made immobile and immaterial is called abstraction. Abstraction, the process in the mind by which things mobile are rendered immobile and things material are rendered immaterial, is not the apprehension of things. It puts what is mobile and material into an immobile and immaterial status so that apprehension or understanding can occur. Before our mind understands, it must make things understandable. It is this process of making things understandable by immobilizing or dematerializing them that we call abstraction.

There will be as many different basic kinds of science as there are different kinds of immobility or immateriality; or putting it in another way, there are as many different kinds of science as there are levels or orders of abstraction. Hence, the principle of division in our project to distinguish sciences from one another in the most general way is the level of abstraction which each science employs. There is another way of stating the principle of dividing sciences. If demonstration depends on definition, there will be as many different basic sciences as there are different levels or orders of definition,[41] and such levels are achieved by abstraction. And, as we shall see, there are three orders or levels of abstraction.

To say that the basic sciences are divided by (a) three kinds of immobility; (b) three kinds of immateriality; (c) three orders of abstraction; or (d) three modes of definition is to say the same thing.

VI. THE PHYSICAL ORDER OF ABSTRACTION

a. Common *Sensible Matter*

In the first order of abstraction, the intellect, operating upon the data

presented to it by the various senses and dematerializing such data in order to make things intelligible, leaves aside what is called individual sensible matter but retains, in abstracted form, what is termed common or universal sensible matter.[42] Such a level of consideration is called the physical order of abstraction, and the object on this level is considered to be in common sensible matter.

Tire difference between individual and common matter here can be best brought home by example. Individual sensible matter is this stick or that stone existing with their sensible qualities as individual things outside the mind; common or universal sensible matter in the foregoing two cases would be stick in general or stone in general. Such matter is called common or universa] because the intellect relinquishes the individual characteristics of the objects brought to it by the senses and considers such objects on a general level.

It is important here to grasp the difference between the universal and the individual. This individual stone exists in this place and at this time; it has a certain color, texture, size, and shape, characters that belong to it and to no other stone in the universe. But the human scientist has to generalize. He wants to make propositions like "All stones are hard"; and to generalize in this way, he must consider his objects at their universal or common level. Hence, the matter considered at the physical level of abstraction has a universal or common character as opposed to the individual character of matter as known by our senses. It is necessary to regard physical things on a universal level in order to make our inquiry into physical things scientific.

Our definition of the first or physical order of abstraction said that the object here is considered not only in common or universal matter but in common or universal sensible matter. The reason is that what the intellect considers at the physical level of abstraction is still regarded as having sensible qualities and may properly be said to be in sensible matter. The stone, even when considered at a general level, is regarded as being heavy, hard, gray, round, etc., and all of these are sensible qualities. All such characters, even though sensible, are considered in a universal form by the science of nature. This is the meaning of universal or common sensible matter. The science of nature must consider its object in a universal way because it is science; it must consider its object in sensible matter because such a science is about nature. To summarize, then, in the first or physical order of abstraction, the intellect leaves aside individual sensible matter while retaining in its consideration common or universal sensible matter.

b. Our *Definitions Include Motion*

So far, our project to characterize the physical level of abstraction has proceeded by showing the kind of immateriality present at this level. It is also possible to identify physical abstraction in terms of its reference to motion.[43] The object of physical knowledge depends on motion in order to exist and in order to be defined or understood by our human science. The mind here leaves aside the individual motions of things and considers these motions at a universal level. In immobilizing physical realities we take them out of their movable status as physical things while retaining, in our universal concepts of physical objects, their reference to motion. The object's immobility is due to its universality. Water, oak trees, iron, and all other physical or natural things involve motion in their physical existence; they come to be and pass away. Moreover, our science of such things must take their changes or motions into account. We know physical things only by what they do, by their actions and their interactions, by their mode of coming into being, by the way their motions affect our instruments of measurement, by their sounds, tastes, smells, reflections of light waves, and other operations. Physical things form the world of motion, and in order to study them in a physical way, they must be understood or defined in reference to motion, with motion understood as any type of change.

It is in this physical order of abstraction that physical or natural science will be found, the kind of science that this book intends to present. If, in order to designate the object of our science, we emphasize the conditions on the part of our knowing power, we can say that the object of our science is sensible material being (considered at a universal or common level); this might be abbreviated to read that the object of our science of nature is material being. If, on the other hand, in order to designate the object of our science we emphasize conditions in the object itself, we can say that the object of our science is mobile being (considered at a universal or common level). Even though either expression may be used, to name our object as mobile being is more exact than to call that object material being. For when we say mobile being, we are talking about what is involved in the object as object in its intrinsic character, whereas in calling it material being we are referring to what is involved in the conditions, on the part of our mind, to apprehend the object.

So much then for the first or physical order of abstraction. At this level the mind leaves aside individual sensible matter but not common sensible

matter. In the physical order of consideration, the object involved depends on motion in order to be in reality and to be conceived in our science of that reality.

VII. THE MATHEMATICAL ORDER OF ABSTRACTION

a. *Universal Intelligible Matter*

The second or mathematical order of abstraction is more complicated. Once more, it can be characterized by the kind of immateriality which mathematical objects possess when we consider them, or by the kind of reference which mathematics makes to motion; and once more a beginner can feel free to use either of the two approaches to mathematical science.

In the framework of immateriality, the mathematician in his strictly scientific character is said to leave aside all sensible matter and to retain in the abstracted result universal intelligible matter.[44]

Intelligible matter ought to be illustrated before beginning an inquiry into its universal or common character. Intelligible matter can be exemplified by arithmetical realities, like the number 2 or the nature of a sum, and by geometrical realities like the triangle or the circle. It is apparent that such objects have no sensible characteristics, and if for no other reason they can be called intelligible. In the number 2, for instance, there is no combustibility or texture as there was in our previous example of the stick; in the triangle, there is no hardness or weight as there was in our stone. Such realities are not sensible; they are intelligible (imaginable) only. Yet they are in a matter of some sort because they have parts; and in the case of geometrical objects like the triangle or circle, the parts are extended in space. Intelligible (imaginable) matter is substance insofar as it is subject to quantity, a definition that will be explained in Chapter VIII. Until this explanation can be given, our examples must suffice to identify intelligible matter as intelligible because our senses cannot perceive it, and as matter because it has parts.

As sensible matter was found to have a twofold character, so intelligible matter is either individual or common. Individual intelligible matter may be instanced by this triangle or that occurrence of the number 2. Each of these realities is an individual like this stick or that stone, and just as there is no properly scientific knowledge of this stick or that stone but only of stone in general, so there is no mathematical science of this triangle

or that occurrence of the number 2. Each is individual, whereas to be treated scientifically each must be treated at a general or common level. Hence, mathematical science must make an abstraction to universal intelligible matter, to the triangle in general as contrasted with this individual triangle and to the number 2 in general as contrasted with that particular case of the number 2.

The mathematician, scientific in Aristotle's sense, makes two abstractions: one, to go from the sensible world to the order of individual intelligible matter; the other, to go to the universal or common consideration of intelligible matter itself.[45] It is not important here which abstraction occurs first or whether there is any time-lag between them. The only point is that there are two abstractions in mathematical science.

The second kind of abstraction — from the individual to the universal — is like the abstraction made in physical knowledge. In fact, every human science has to make this kind of abstraction simply because all scientific knowledge occurs at a universal level and requires general propositions. But the first kind of abstraction that we have found in mathematics, the abstraction from sensible reality to individual intelligible matter, is not required in the science of nature. The reason is that nature is already proportioned to our knowing powers, and to study nature in a scientific way requires only going toward the universal or common principles within the physical universe while still considering that universe. The science of nature does not leave behind the physical or natural world.

But the mathematician does. He has to make an abstraction to go from the physical world to the mathematical world. He has to go from sensible to intelligible matter, and like any other scientist, he must proceed to the universal level within the intelligible matter which his first abstraction has yielded. The abstraction from sensible to intelligible matter is required of mathematical science because it is mathematical; the abstraction from individual intelligible matter to universal intelligible matter, is required of mathematical science because it is scientific. Science is taken once again in Aristotle's sense.

b. *Mathematical Definitions Do Not Include Motion*

Capable of being identified by its peculiar kind of immateriality, mathematics can be characterized also by its relation to motion.[46] Whereas at the physical level the scientific object depends on matter both for its existence and its definition, the mathematical object depends on motion for its actual existence but not for its mathematical definition. The

2 of arithmetic and the triangle of geometry have real existence only in the physical, natural, mobile world; but in our mathematical science, we leave aside the mobile or physical surroundings in which mathematical realities are found.

Mathematical objects are thus considered without reference to their being in the world of motion. There is no disintegration of the number 2 as there is a breakup of radioactive atoms; there is no growth to a triangle as there is growth in a leaf. Thus while mathematical entities exist only in the moving world, the mathematician in his science leaves their motions aside. That is why we can say that although the object in the science of nature, i.e., material or mobile being, depends on motion for being and for definition, the mathematical object, i.e., quantified being, depends on motion for being but not for definition.

There is another kind of science intermediate between the physical and the mathematical. It is properly called mathematical physics. However, this "mixed" kind of knowledge is not one of the basic sciences but a combination of two of them. It will be considered at length in Chapter VIII and can be disregarded here.

VIII. THE METAPHYSICAL ORDER OF ABSTRACTION

a. Objects *Without Matter*

The third order of abstraction is the metaphysical. The metaphysician leaves out of account not only sensible matter but even intelligible matter.[47] Hence, metaphysics relinquishes from its considerations any reference to matter at all. Examples of metaphysical questions are: what is being, cause, substance, relation, act? Such realities do not depend upon matter in order to exist. They apply to all being, material or not, and even though they may exist in matter, they need not exist there. They could exist if there were no material world at all. Metaphysics, the science of being as being, leaves out of its focus all reference to matter. It studies not mobile being or quantified being but being without qualification. It is also proper to characterize metaphysics as natural theology. As a science, it studies the cause of its subject, namely of being, and hence it does not become fully scientific until it considers the cause of being who is God.

Like the mathematician, the metaphysician must make two abstractions: one (only loosely an abstraction and more properly an operation

of a different type called separation) in order to reach the metaphysical level; the other, in order to abstract the general from the individual within the metaphysical level of knowledge and thus to construct a science. The first abstraction makes metaphysics or natural theology to be metaphysical, and the second makes it to be scientific.

b. *Objects Without Motion*

In reference to mobility, metaphysics or natural theology considering being in general deals with an object that has no need of motion to be or to be understood.[48] Substance, cause, and other such realities may, of course, exist in motion, but this special kind of existence is not necessary to their natures. They do not require motion in order to exist. Considering them in a common or universal way and as applying to all things mobile or not, the metaphysician does not use motion in order to understand and define them. They therefore do not depend on motion either to be or to be understood.

c. *The Unfamiliarity of Metaphysics*

Many readers of these pages will no doubt have great difficulty in recognizing that there is a science called metaphysics and in realizing what the object of this science really is. College students, even if they have been unaccustomed to using the term science after the fashion of this chapter, have had at least some measure of physical knowledge from previous studies. They also know in some way what mathematics is about. But metaphysics is something quite foreign to their previous experience, and it is not easy to make clear what this science concerns until a student is actually studying metaphysics. More will be said in Chapter XIX concerning metaphysics or natural theology, and our human way of discovering that there is such a science. Prior to this it will be important to keep in mind only the difference between physical science and mathematical science, between sensible matter and intelligible matter, between what depends on motion for existence and for definition and what depends on motion only for existence but not for definition.

IX. SUBJECT OF A SCIENCE

The object of a science is that which primarily and essentially confronts the mind in that science. In an introductory work of this sort, it is pos-

sitie to use the terms subject and object interchangeably. These expressions really refer to the same thing from different points of view. The subject[49] of a science is that about which the science in question seeks to learn; it is what the science is about. In the language of logic, it is that to which the predicates in a science are applied or that about which there is demonstration. It is a genus of things which the mind comes to know in a more and more perfect manner as the science in question advances. To speak of the subject of a science should have a familiar ring to anyone with a knowledge of logic. Object means the same thing as subject, but in a context of psychology rather than logic. Once we have abstracted an object we consider it as a subject in our logical operations. Subject and object, since they designate the same reality, will be used interchangeably throughout the following pages, but subject will be preferred in discussions of the logical operations within a science.

X. SUMMARY

In this chapter, science in its Aristotelian sense was defined and explained as a certain knowledge in terms of causes, and demonstration was defined as a syllogism producing science. It was further shown that knowledges are divided in terms of objects and that, in their most general division, sciences, as knowledges, are differentiated from each other by the differences among objects which they concern. There is a realm of physical science, dealing with material or mobile being, in which the object is conceived in common sensible matter and in which the object depends on motion to be and to be understood. There is a second kind of science, called mathematics, dealing with quantified being where the object is conceived in common intelligible matter and where the object depends on motion to be but not to be understood. A third kind of science, metaphysics or natural theology, dealing with being as being, has an object conceived without reference to matter and without dependence on motion to be or to be understood. The object of a science is the same reality as the subject of a science, and for present purposes the two terms may be used interchangeably.

REVIEW QUESTIONS

1. Contrast science in the modern sense and science in the Aristotelian sense.
2. Define science in the Aristotelian sense and define demonstration; relate the two definitions.

3. Show why any science in the Aristotelian sense requires not only principles but first principles.
4. What is meant by the term *object?*
5. Why is it proper to divide sciences according to their differences in object?
6. Why is it necessary to abstract in order to reach scientific knowledge?
7. Explain the three levels of abstraction which provide the basis for dividing the sciences.
8. Compare the *object of* a science with the subject of a science.

PROBLEMS

I

Write a brief paraphrase of every one of the following sentences giving examples to show what each sentence means:

> "We think that we know a thing in an unqualified way . . . when we think that we know the cause on which the thing depends as the cause of that very thing and that the thing could not be otherwise. Now it is evident that science is something of this sort. Take for example those who do not know and those who really do know: the former merely imagine themselves to be in this condition, whereas the latter are actually in it. Therefore, the object of unqualified science is something which cannot be other than it is.
>
> "We will discuss later whether there is another manner of knowing, but for the present I do say that we know by demonstration. By demonstration I mean a syllogism which produces science; by producing science I mean such that by the very grasp of it we possess science. If then science is such as we have laid down, the premises of demonstrative knowledge must be true, primary, immediate, better known than, and prior to the conclusion, and the cause of it as well. If these are so, then the first principles will be appropriate to the proof. A syllogism will be possible even without these, but it will not be demonstration, for it will not produce science."
>
> Aristotle, *Posterior Analytics*[50]

II

Check the following passage against the explanation of the division of science given in the present chapter:

> "Because the book of the *Physics* whose exposition we intend is the first book of Natural Science, it is necessary at the outset to designate what is the subject matter of Natural Science.
>
> "It should be understood that since all science is in the intellect, anything becomes actually intelligible to the extent that there is a measure of abstraction from matter; according as any objects are diversely related to matter they pertain to diverse sciences. As another way of putting it, since all science is the product of demonstration and since the middle term of demonstration is definition, sciences are necessarily diversified according to their diverse modes of definition.

"Accordingly, it should be understood that there are certain things whose existence depends on matter and that they cannot be defined without matter; there are also certain things which, although they cannot exist except in sensible matter, do not include sensible matter in their definition. And such things differ in the fashion of the curved and the snub; for the snub nose exists in sensible matter, and it is necessary that such matter be included in its definition; (for the snub is a curved nose); the same thing holds of all natural things, such as man and stone. The curved, however, although it cannot exist except in sensible matter, does not include such matter in its definition; the same thing holds of all mathematical realities as numbers, magnitudes, and figures. There are also certain things which depend on matter neither to exist nor to be understood; either because they are not always in matter or because they are sometimes in matter and sometimes not, as substance, potency and act, and being itself. Such realities are treated in metaphysics; mathematics is about those things which depend on matter in order to be but not in order to be understood; concerning those things which depend on matter in order to be and also in order to be understood there is natural science, which is also called physics.

"And because everything having matter is mobile, it follows that mobile being is the subject of natural philosophy. Moreover, natural science is about natural things; what is natural is that whose principle is nature; nature is the source of motion and of rest in that in which it is; natural science therefore is about those things which have in themselves a principle of motion."

St. Thomas Aquinas, Commentary on *the Physics of Aristotle*[51]

III

Write a comparison of the relation between the physical and mathematical as illustrated in the following passages, paying special attention to terms like *abstract, concrete, material, matter.*

"... I desire, before passing on to any other subject, to call your attention to the fact that these forces, resistances, moments, figures, etc., may be considered either in the abstract, dissociated from matter, or in the concrete, associated with matter. Hence the properties which belong to figures that are merely geometrical and non-material must be modified when we fill these figures with matter and therefore give them weight."

Galileo, Dialogues Concerning *Two New Sciences*[52]

"[In discussing the parabolic path of a projectile,] I grant that these conclusions proved in the abstract will be different when applied in the concrete and will be fallacious to this extent, that neither will the horizontal motion be uniform nor the natural acceleration be in the ratio assumed, nor the path of the projectile a parabola, etc."

Galileo, *ibid.*[53]

NOTES TO CHAPTER I

1. St. Thomas, On Being and Essence, transi. A. Maurer (Toronto, 1949), Introduction, p. 25; cf. also, Aristotle, On *the Heavens,* Bk. I, ch. 5, 271b, 13–14; and St. Thomas' commentary, Bk. I, les. 9; also Com. on Eth., Bk. VII, les. 8, n. 1432.
2. For one of the many references to this point, cf. Com. on the Trin., q. 6, a. 1, 2nd q., reply 3; cf., also, John of St. Thomas, *The Material Logic of John of St. Thomas,* transi. Y. Simon and others (Chicago, 1955), p. 3 ff.
3. *Exposition of the Post. Anal.,* Prologue, 1.
4. Education: *Intellectual, Moral, and Physical* (New York, 1900), p. 119.
5. *Eight Lectures on Theoretical Physics* (New York, 1915), p. 3.
6. Aspects of *Science* (New York, 1947), p. 280; J. Maritain has highlighted the interest of modern physics in the measurable in *Les Degrés du Savoir* (Paris, 1932), p. 286 ff.
7. *Mathematical Principles of Natural Philosophy,* transi. A. Motte, rev. F. Cajori (Berkeley, 1947), p. 547. Citations from Newton's *Mathematical Principles* are reprinted with the permission of the University of California Press. For the meaning Newton attached to his *hypotheses non* fingo, cf. L. Stebbing, A Modern Introduction to *Logic* (London, 1930), pp. 314-316.
8. Post. Anal., Bk. I, ch. 2, 71b, 8-16; Exposition of the *Post. Anal.,* Bk. I, les. 4, 5.
9. *Post.* Anal., Bk. I, ch. 2, 71b, 17-18.
10. For a biography, cf. A. Taylor, Aristotle (New York, 1955).
11. For a biography, cf. G. Chesterton, St. *Thomas Aquinas* (London, 1933).
12. Com. on On *the Heavens,* Bk. I, les. 22.
13. Galileo envisioned himself as constructing new sciences; cf. his title, Dialogues Concerning *Two New Sciences.* One of the "new" sciences concerns "the resistance which solid bodies offer to fracture"; and the other concerns "local motion."
14. **Bacon regarded himself as providing,** in the words of his own title, The *New* Organon; or True Directions concerning the Interpretation of Nature. This new organon or new logic was to be inductive in an overly empirical sense of the term.
15. Cf. P. Frank, Philosophy of *Science* (New York, 1957), pp. 42-43.
16. Although this book covers what is usually called the philosophy of nature, I have avoided using the term philosophy to characterize its content. The reason is that philosophy as used today is almost an equivocal term. What is taught in our philosophy departments usually includes at least four distinct sciences, and to use one name for all of them is no longer good semantics. On this point, cf. F. Connolly, Science versus Philosophy (New York, 1957), p. 15 ff.; P. Conway and G. Friel, "Farewell Philosophy," The *New Scholasticism, XXIV* (1950), 363-397.
17. Post. Anal., Bk. I, chs. 2-3 (passim); Exposition of the Post. *Anal.,* Bk. II, les. 3, n. 4.
18. Exposition of the Post. *Anal.,* prologue.
19. Com. on the *Met.,* Bk. 4, les. 4, n. 574; Com. on the *Trin.,* q. 6, a. 1, 2nd. q.
20. On the Revolution of *the Heavenly Spheres,* "Great Books of the Western World," ed. R. Hutchins (Chicago, 1952), XVI, 528.
21. We should not put too much stock in a merely "possible solution" to physical problems. Cf. Com. on *the Meteor.,* Bk. I, les. 10; Summa *Theo!., I,* q. 32, a. 1; Com. on On the Heavens, Bk. II, les. 17.
22. Post. Anal., Bk. I, ch. 2, 71b, 10-11. *Exposition of the Post. Anal.,* Bk. I, les. 4, n. 5.
23. Exposition of the *Post Anal.,* Bk. I, les. **23** (passim); Summa *Theol.,* 1, q. 2, a. 2; Com. on Eth., Bk. 1, les. 4, n. 51.
24. Exposition of the Post Anal., Bk. 1, les. 4.
25. For a study of demonstrations and their use in our knowledge of nature, **cf.** A. **Wallace, "Some** Demonstra-

tions in the Science of Nature," *The Thomist Reader,* 1957, ed. The Dominican Fathers of the Province of St. Joseph (Washington, 1957), pp. 90-118. Cf. also M. Glutz, *The* Manner of Demonstrating in Natural *Philosophy* (River Forest, 1956).

26. Summa *Theoh, I,* q. 33, a. 1; Met., Bk. V, ch. 1 (passim).
27. Com. on the Phys., Bk. I, les. 1, 5. (References to lessons in the first two books of St. Thomas' Com. on the Phys, are to the edition of R. A. Kocourek, An Introduction *to the Philosophy of Nature,* rev. ed. [St. Paul, 1951]. References to lessons in Books III through VIII are to the Angeli-Pirotta edition [Naples, 19531.) Com. on *the Met.,* Bk. V, les. 1, n. 751; Sum. cont. Gen., Bk. II, ch. 11.
28. Com. on the Phys., Bk. I, les. 1, 5; Com. on *the Met.,* Bk. V, les. 1, n. 750.
29. *Com. on the Phys.,* Bk. I, les. 1, 5; On the Power of God, q. 10, a. 1, reply 8.
30. Prine, of Nat., 22.
31. Com. on the Phys., Bk. I, les. 10, 3.
32. On the Power of God, q. 1, a. 3, reply 8.
33. Cf., for instance, On Truth, q. 10, a. 12; Exposition of the *Post. Anal.,* Bk. I, les. 5, n. 7.
34. On Truth, q. 11, a. 2, reply 17; a. 1, reply 13; q. 12, a. 1; q. 16, a. 2; cf. Phys., Bk. I, ch. 1, 184a, 9-16.
35. On Truth, q. 22, a. 1; q. 14, a. 9.
36. In dividing the sciences in his Com. on the Trin., q. 6, a. 1, St. Thomas speaks of "objects" of science; in another explanation of the division of the sciences, Com. on the Phys., Bk. 1, les. 1, 4, the language used is "subject," at least in discussing natural science; cf. also Summa Theoh, 1, q- I-
37. Cf. Summa Theoh, I, q. 85, a. 8.
38. Com. on the Trin., q. 5, a. 1. The principal discussion concerning the orders of abstraction will be found in Com. on the Trin., qq. 5 and 6; Com. on the Phys., Bk. 1, les. 1, 2; Summa Theoh, I, q. 85, a. 1, reply 2; cf., also, J. Maritain, Philosophy of Nature (New York, 1951), pp. 12 ff; W. Kane, "Abstraction and the Distinction of the Sciences," The Thomist, XVII (1954), 43-68.
39. Com. on the Trin., q. 5, a. 1.
40. Ibid.
41. Com. on *the Phys.,* Bk. 1, les. 1, 1.
42. Summa *Theoh,* I, q. 85, a. 1, reply 2; Com. on the Phys., Bk. I, les. 1, 2.
43. Com. on the Trin., q. 5, a. 2.
44. Summa Theoh, I, q. 85, a. 1, reply 2.
45. Com. on *the Trin.,* q. 5, a. 3.
46. Ibid.
47. Summa Theoh, I, q. 85, a. 1, reply 2.
48. Com. on the Trin., q. 5, a. 4.
49. Exposition of the Post. *Anal.,* Bk. I, les. 15, 3; les. 41, 7.
50. Ch. 2, 71b, 8-22. From the mimeographed translation of Mr. Leroy Smith, of St. Mary's College, California.
51. Translation mine, from the Angeli-Pirotta edition (Naples, 1953), Bk. 1, les. 1, nn. 1-4.
52. New York, 1914, p. 154.
53. Ibid., p. 274.

CHAPTER II

THE SCIENTIFIC APPROACH TO MOBILE BEING

I. MOBILE OR MATERIAL BEING

The subject or object of the science of nature may be best designated as mobile or changeable being,[1] with motion or mobile taken in a sense wide enough to include any physical change. If the term mobile being seems awkward, we can call our subject material being; but material being would have to be understood as the equivalent of movable or mobile being if we are to avoid that small error in the beginning of a subject matter which can grow to a large error later on. Just as we agreed in the past chapter to use subject and object interchangeably, so, unless otherwise indicated, material and mobile will from now on be taken as synonyms, and mobile will mean what is in any way physically changeable.

Even if the term mobile being is clumsy, it has the merit of exactness in meaning. Mobile being is the object of our science because it is that with which our science is concerned, much as the colored is the concern of our power of sight. Material being or mobile being, if these two expressions can be taken as synonyms, is the subject of all predication in our science. It is that about which, through appropriate middle terms, our demonstrations in the science of nature will be made. Strictly speaking, mobile being is what our science is about and material being is involved in our abstraction for considering it.[2]

There are several reasons for considering the object or subject of our physical, natural science to be mobile being or, where the material is taken as the mobile, to be material being.[3]

a. *Ths Obvious Fact of Motion*

In the first place, as shown by its Latin root, mobile means that which is capable of being moved. Material once meant the very same thing, i.e., what is capable of motion.[4] Now the most obvious fact about our universe is its mobile or changeable character, its power to come to be and pass away. Everything in this world is either in motion or capable of being in motion. Permanent as even the sun and stars appear, they perform a familiar relative motion with respect to the earth; and man himself, the greatest of visible creatures, comes to be and passes away. Listen to the way the poet puts it.

> The tusks that clashed in mighty brawls
> Of mastodons are billiard balls.
>
> The sword of Charlemagne the Just
> Is ferric oxide, known as rust.
>
> The grizzly bear whose potent hug
> Was feared by all is now a rug.
>
> Great Caesar's bust is on the shelf,
> And I don't feel so well myself.[5]

b. *Motion as a Test of the Reality of the Physical World*

Second, not only is motion the most obvious fact about our world, but it is motion which awakens us to the reality of that world. The test of whether a thing is physically real or not is whether it can interact with our own bodies, hurting or helping us in a physical way or responding in some other manner to our sense of touch. Were it not for motion, there would be no problems for the human intellect. The fact that things in motion are always changing arouses our wonder and provokes the question, why?, leading us to seek causes and acquire science. We want to know the causes and principles of the mobile beings in our experience; in other words, we want to know more about mobile being, the subject of our science about which predications are made.[6]

c. *Motion as Revealing Natures*

In the third place, not only is motion the most universal characteristic of things we experience and the means of awakening us to the reality of our world, it is also our best source of knowledge regarding the things of our experience.[7] Consider a man sitting on his front porch beside his

dog. If, by a farfetched and even impossible hypothesis, some rational observer whose experience had never included contact with either of these creatures should suddenly chance upon them, he could look at them in their static posture for an indefinite time without ever discovering which was the rational animal or whether either one was rational, or for that matter whether either was an animal. But the moment they began to operate — let us say they were each given a problem in arithmetic or set to the task of constructing a home or disposing of the dead — the great difference between the two animals would begin to emerge. Without studying their operations, our hypothetical observer would be unable to decide whether either of the two objects was rational, animal, vegetable, or even mineral. Indeed, until he observed their independent motions, he might even conclude that the two creatures, sitting together, were actually but one thing joined by a subtle medium of some sort.

The various motions or changes in physical things thus reveal to us something about their natures. No one could decide, apart from the motions of physical things, what the various elements and compounds are; whether hydrogen is combustible, and oxygen not; whether silver is a stable element, and radium not; whether heavy bodies and light ones fall at the same rate; whether a compound can be resolved into elements and elements synthesized into compounds; whether like charges repel, and unlike charges attract; whether the moon affects the tides; whether in an elastic substance stress is equal to strain; whether carbon dioxide and sunlight are necessary to the green plant; whether radioactive fall-out is dangerous; or what the difference is between sickness and health. Motion thus reveals to us the character of the subject which undergoes motion, i.e., the mobile being. Since that about which motion enlightens us is mobile being, mobile being is the subject of our science. What is mobile, to repeat, is that which is capable of motion but need not be moving here and now.

II. AN OBJECTION: KNOWLEDGE THROUGH MEASUREMENT

From the emphasis in modern physics, chemistry, and even biology, it might appear that motion does not have the importance we are assigning to it in revealing what things are; on the contrary, it might appear that our best knowledge of the physical world is obtained by

measurement, i.e., through quantity rather than motion. One of the principal characteristics of science, in the modern meaning of the term, is often said to be the use of mathematics and the study of only the quantified aspects of physical things.[8] Galileo, for instance, discovered mathematical laws to describe the fall of bodies and the behavior of a pendulum. Newton entitled his immortal classic *The Mathematica] Principles of Natural Philosophy;* and, as the first part of its name would indicate, the work is concerned with the fundamental equations that describe our natural universe. If motion is so important in revealing to us what things are, how is it that so much knowledge of our world can be gained through measurement? Perhaps, after all, quantity reveals to us more about matter than motion does.

a. *Measurement Is Secondary in Knowing Nature*

Yet it must be mentioned here that measurement (quantity), whatever its great contribution to knowledge, is not the basic way of knowing that there is motion in our universe, of knowing what motion is, and of knowing what things are in our physical world. In the simple case of a body moving from one place to another, what can measurement reveal to us? The modern physicist measures the path of a moving body; but because the path of such a body is neither the body itself nor its motion, as Henri Bergson so forcefully argued,[9] mere measurement of mobile being presents us only with a static line. Such a line, being static, cannot by itself even hint at the physical event, which is not stationary but mobile. When we know by other, i.e., non-metrical, methods that a body is in motion, the measurement of the path can be related to this non-metrical knowledge, and our knowledge of the motion can in this way be refined. Measurement regarding nature thus becomes a way of knowing more about things which we already know in some way by a method other than measurement. However frequently it occurs or how tremendously important it is, measurement is essentially a way of supplementing and refining what we already know of the mobile world by other non-measuring techniques. In the case of the moving body, measurement of the path can only add to our knowledge when we know by other avenues that motion is occurring and, in some vague way, what motion is. We have to know what it is that we are measuring if we are not to engage in a mere mathematical exercise. The mathematical approach to nature, however important, cannot give us our basic scientific knowledge of physical reality.

b. *Examples to Show the Secondary Role of Measurement*

The present point is so important that some other examples of measurement can usefully be reviewed. Let us look at quantitative techniques in their application to the problem of weight. One way of determining the weight of an object is by means of an ordinary commercial scale like that used in butcher shops or grocery stores. The thing being weighed causes the movement of springs, and the springs in turn move a pointer across a dial where we take our readings. But despite the accuracy attained in measuring weight by this means, there is nothing in the process just described which can tell us what weight is or what it is that is being weighed.

The nature of weight is known to us by holding something in our hands and by experiencing the effort involved in overcoming the downward thrust of the body we thus support. Scales like those in our example can then be constructed to compare the thrust of a body with some kind of conventional standard, like the pound, and in this fashion an accurate determination of weight can be made. But without knowledge obtained by holding a more or less heavy object in our hands, the scale alone cannot tell us what we are measuring.

Readings on a dial can mean a great many things: electrical current, voltage, or resistance; magnetomotive force; temperature; pressure; humidity; light or sound intensity or frequency; and, in our present example, weight. The pointer readings on a dial cannot by themselves tell us what they point to in physical reality. Such readings can refine and supplement knowledge obtained by non-quantitative techniques. And measurement is meaningful only in the light of motions as known in a non-mathematical way — the way in which we know what weight is by holding something in our hand. It is from motion that we get our fundamental knowledge of the physical world; it is from quantitative measurements, as related to this fundamental knowledge, that we get detail and precision within this fundamental knowledge.

Even in measuring the distance to the sun as 93 million miles, it is necessary to go beyond mere measurement to invest our knowledge with physical meaning. In other words, the mathematical concept of 93 million miles must be applied as the distance between the sun —a physical reality — and the earth — another physical reality; otherwise, mere knowledge of 93 million miles, without naming things between which the distance obtains, would be meaningless as a report on the physical universe. In itself it would be interesting only as mathematics.

Measurement is a valuable and necessary technique if our struggle to know the physical world is to proceed very far and very successfully. But it is not the primary and fundamental means *of* knowing physical reality, and it can only refine and enlarge the knowledge already attained in a non-mathematical way. Unless this non-metrical knowledge, e.g., of motion, of weight, of the sun and the earth, is embodied in all knowledge obtained by a quantitative approach to nature, we would not know what it is that we are measuring. It is from motion that we get our basic knowledge of nature; for the most part it is from the quantity which motion involves that we fill in the enormous detail within our basic knowledge. Since the primary and fundamental knowledge of the physical world is revealed by motion, it is fitting to designate mobile being as the subject of our science or, if the material is the mobile, material being.

111. MOBILE BEING IS BETTER KNOWN TO US THAN IS IMMOBILE BEING

In the study of any subject, including material or mobile being, the mind must begin with what is better known and work toward what is less known. This is the fundamental principle of all teaching and all learning. Progress in knowledge is a movement from the familiar world to things that are unfamiliar, from what we know to what we do not know, from what is more intelligible to us to what is less.

a. *The Least Intelligible Reality Most Intelligible to Us*

In order to expand upon this basic principle of learning, a distinction must be made between things that are more intelligible to us and things that are more intelligible in themselves. What is most intelligible to us is ordinarily least intelligible in itself, and what is least intelligible to us is what is ordinarily most intelligible in itself.10 The world around us is more intelligible to us than the angels and God who are above the physical universe. But this world around us that we find most fitted to our knowing powers and hence most intelligible to us is less intelligible in itself than, say, an angel. Being immaterial, an angel is, absolutely speaking, more intelligible than any material thing, but relatively to us an angel is less intelligible than mobile reality. God is supremely intelligible in Himself, but to us who in the natural order know Him only by His effects, He is the least intelligible of all things.

b. We *Begin With Material Things*

Progress in human knowledge from the better known to the less known is a movement of the human mind from what is more intelligible to us but less intelligible in itself to what is more intelligible in itself but less intelligible to us. This proposition will govern our divisions of the various sciences into the order in which they are learned. It is a principle that should dominate the whole life of learning. In the natural order, logic would require that scientific knowledge of the material and mobile world precede the study of what is purely immaterial and immobile. Things existing in sensible matter and depending on motion in order to be and to be understood should be considered prior to things that do not exist in matter and depend on motion neither to be nor to be understood.[11] In order of learning, the science of mobile or material being precedes the science of being as being and, as will be later seen, prepares for it.[12] Until proved otherwise, mobile being is the only kind of separately existing being our mind knows.

In going from what is more intelligible to us to what is more intelligible in itself, then, mobile being should be examined prior to the study of being as being. But within the world of motion, what should be studied first?

c. *What Part of the Material World Is Best Known to Us?*

To this question, a number of answers might possibly be given. Some might argue that a science of nature begin with Galileo's experiments on falling bodies. Others, as their textbooks show, would begin with Newton's laws concerning local motion. Still others start with the principle of Archimedes in regard to the lever. Descartes wanted to open natural science by the study of light.[13] Why not begin our study of nature with the atomic theory or at least with a classification of matter according to the periodic chart? Other points of departure for the study of mobile or material being might be astronomy or even the world of living things, including man himself. All of these considerations appear as possible starting points for the study of material being. Which of them concerns the mobile world in the form that is most intelligible to us? Which, if any of these various kinds of motion, can furnish the first principles of material being, the starting points that make it possible to construct a demonstrative science of nature?

IV. GENERAL AND VAGUE KNOWLEDGE IS EASIER

The answer to our question requires a respect for the order of learning. Granted that the sensible must be studied before the intelligible and the mobile before the immobile, what part of the sensible and mobile world must be studied first?

In order to reach a decision on this problem, it must be observed that the human intellect works from the general to the particular or specific, from the confused to the distinct, from vague and confused knowledge to knowledge that is more precise and detailed.[14] This is the order of intellectual knowledge, and this order in the intellect, where alone science exists, is the only order we are considering. If this is so, then the logical order of any science, as dictated by the very nature of human intelligence, is to begin with most general and vague considerations and work toward those that are progressively less general and less vague.

Absolutely speaking, human knowledge begins with the particulars grasped by our senses, and the ensuing movement from sensed particulars to universal concepts is what has previously been called abstraction. Another word for this abstraction is induction.[15] Tire inductive or abstractive movement from the singulars of sensation to the universals formed by the intellect is not of immediate concern here.

Our question rather concerns the direction or order within the intellect itself. Given the sensation of this individual stick or stone, and given that the intellect is now going into action upon it, what does the intellect first apprehend about the object under consideration and in what order does the intellect proceed in making this first knowledge of the object grow more perfect? The answer is that, given sensation, the intellect first forms the most general, confused, and vague knowledge of the object under consideration and that, as knowledge of this object becomes more perfect, the notions in the intellect become more particular, distinct, and precise.

Such an analysis requires proof. Two examples or signs will be presented to support our conclusion, and the conclusion itself will then be shown to follow from a principle that everyone would admit.

a. *Proof by Common Example*

A classic example, to show that the human intellect begins with general,

confused, and vague knowledge of any object and works toward more particular, distinct, and precise notions is the case of a man walking down a road and sighting a distant object.[16] At first, he will have only the haziest notions about the visible thing, not knowing perhaps anything at all about it except that it is, like all other matter, a thing. As he approaches closer to what he first recognized as only a thing, our pedestrian begins to recognize more distinct features of the object. If it is moving he will know that it is living. At a still closer approach, our observer will recognize even more precise details, e.g., the animal is a quadruped. As the distance continues to lessen, the person may have enough knowledge to know that the animal is a rodent, and finally, on getting still closer, he will see that what was originally called only a thing or an object is, let us say, a squirrel.

Such is the direction taken by intellectual knowledge. In intellectual life as a whole, there is a growth from universality and vagueness to particularity and precision, and in experiencing any new object for the first time, more general, confused, and indistinct ideas about it occur first, followed by more particular, distinct, and precise notions. Our squirrel may be recognized as a familiar object by anyone who comes upon it suddenly by looking out a window and seeing the animal in his yard or on his porch roof. But if such knowledge is to increase still further, it will move in the direction of more particular detail and concreteness. This is to say that if we wish to know more about the squirrel that appears suddenly before us and is immediately recognized as a definite animal, a squirrel, such an increase in knowledge will involve more about the details of the animal's life until finally it will be necessary to enter the technical world of anatomy and physiology of the thing to continue our knowledge. Increase in knowledge on the part of the human intellect is thus a movement from the relatively more general and confused to the relatively more particular and distinct.

b. *Another Example: The Behavior of Children*

As another sign of how the intellect moves from vague knowledge to more perfect notions,[17] a baby will first call all women by the same name, "mama," because the infant does not have enough distinct knowledge to differentiate one woman from another. As his knowledge increases, the child will put distinction and differentiation into his notions and in this way will have a greater awareness of the difference between his own mother and other women. In articulating language, children first use nouns

and verbs, the most general parts of speech, and only later do they know enough to employ the other parts of speech which are particular and specific refinements of the noun and verb.

c. *Proof by Principle*

A principle can also be invoked to prove our present point.[18] The work of human reason is, in a broad sense, a kind of movement from one thing to another. Like all movement human knowledge about anything reaches its perfection in gradual stages, as our whole educational system from kindergarten through graduate school bears witness. Our intellect proceeds from potency to act. As a capacity for knowledge it progresses through various intermediary stages in its advance from ignorance to complete and perfect knowledge. These intermediary stages constitute imperfect, imprecise knowledge. This is but another way of putting the proposition that, as human knowledge advances, it first grasps those aspects which a thing shares in common with other things, and later on it comes to know those properties peculiar to the reality in question. For the intellect to reach its perfection by gradual stages means to begin with the imprecise notions of things and work to the proper ones. This is the natural direction of our mind in all knowing.

d. *A Possible Misunderstanding*

It would be naïve to suppose that, upon encountering any object in our experience, there is a distinct moment when our intellect understands its most general characteristics, then a pause followed by a grasp of those characteristics which are slightly less general than the first, until ultimately the intellect seizes those properties which make this object to be what it is. When the mind's knowledge of a thing increases, there is a growth from the more universal and confused notions to more particular and distinct notions. But ordinarily there is no temporal lapse in a mature mind between recognizing a squirrel in a vague way as an object and recognizing it in a more distinct way as a squirrel. Because of previous experience which has enabled us to form habits of looking at reality, things like sticks or stones or squirrels are recognized immediately to be what they are. Nevertheless, in any concept we reach concerning material things, a confused knowledge is implicitly and logically prior to knowledge that is more particular and distinct. In other words, as we cultivate the habits which enable us to identify objects of our

experience in a fairly distinct and particularized way, the more general and vague notions are formed first, and they remain implicitly or logically first even though we appear to recognize familiar things at once as being what they are, with no time lag involved.

V. ORDER IN THE STUDY OF NATURE

a. What Is *First in Our Science of Nature?*

If general and confused notions about material being are implied by the more proper and precise notions, it follows that any attempt to achieve a complete science of nature must begin with universal and vague notions concerning the mobile world. If we are to start at the beginning of our subject, logic requires that the most universal aspects of material reality be analyzed first. The mind, commencing a study of nature in this fashion, begins with first principles like those illustrated in the past chapter and thus provides the groundwork for the certain knowledge of things in terms of proper causes, which is science in the best sense of the word.

Tire appropriate way to erect a tota] science of nature, sure of itself from the start, is not to begin with the equations for falling bodies or with Newton's laws for local motion. An analysis, scientific in Aristotle's sense and hence beginning with first principles, will not start with astronomy or atoms or living things. All of these starting points would involve particular principles or particular types of material being. Falling bodies, movements of the stars, or motions in the living world are special or particularized kinds of movement with specialized or particularized principles. What the mind knows first, and what therefore ought to be first considered by a science in the Aristotelian sense, is not the special and the particular but the general and the vague notions of our material world. It is at the general and vague level that things are more intelligible to us, and it is here that we will find the first principles of our science of nature, if such principles can be found at all.

Science is a kind of "art" added to our natural intelligence. If our intellect of its own self tends to go from the general and vague to the more particular and more exact, our science of nature should follow a similar order. This means that more general aspects of the material world must be examined first. It means that mobile being in general should be con-

sidered before an analysis is made of special kinds of mobile being and special kinds of motion. It means that our first principles or starting points for the study of nature will be the most universal principles of material things.

Although vague and general notions about the physical world are most readily understood by us, they are not as intrinsically intelligible as those more precise and specific notions which are harder for us to grasp. The refined and distinct knowledge of our world which we gain, for example, in modern biology, is quite difficult; to attain it requires greater mental ability than that demanded for gaining a knowledge of the more general aspects of nature.

b. Science *in Its Aristotelian and Modern Senses*

Even though common and confused notions about the material world are relatively easy to reach, they are by no means trivial and irrelevant. They come at the beginning of our study of nature. They are so easy, as Chapter IV will show, that they slip, almost subconsciously, into our mind. Being easy and unobtrusive, they are so much unnoticed that the modern investigator of nature, concentrating on detailed and distinct knowledge, is unaware that these general notions, which are logically prior to any subsequent knowledge of physical reality, exist in his mind; he thus feels able to dispense with such notions and to construct an organized knowledge of nature without them. But even if they are so easy and so unobtrusive as to escape awareness, they are yet present to the mind prior to its more precise notions, and if they are not properly analyzed, serious errors may result in the development of a science of nature.

Probably no knowledge is more important to us than the notions which are common and confused. General knowledge is not ignorance, and vague and confused notions are not error. On the contrary, our universal notions about nature, vague and common as they are, form our most certain knowledge of the physical world. They give meaning to all other knowledge of nature. As the mind moves to more refined and distinct notions, confusion gives way to clarity. But at the same time there is a loss of certitude in our knowledge. Modern research into nature, as in the study of atoms and their parts, yields a mine of rich detail, but our certitude has wavered to the point where explanations are only hypothetical and where dialectic takes the place of demonstration.

c. *The Unity of Mobile Being as an Object*

According to the view proposed here it would be inaccurate to regard mobile being as open to study by two distinct sciences, one considering it at its general level and the other considering it in a more proper and precise way. Knowledge that begins with general considerations concerning an object naturally tends to become more precise; unless it does so, it remains intrinsically imperfect. The same science that studies the first principles or ultimate causes in a given order of reality tends, by its intrinsic nature and not by any external force, to complete itself by the study of proximate causes. We do not change sciences in moving from a general to a particular level, so long as we do not change objects. What we do is to change the perfection in our knowledge of the object; we are like the man who recognized the distant object first as only a thing and later came to the much more perfect knowledge of it as a squirrel. Particular scientific knowledge is more perfect since it is more specific, although, from another angle, it is less perfect since it is less certain. General scientific knowledge is more perfect in being more certain but less perfect since it is not proper and precise.[19]

VI. THE GENERAL SCIENCE OF NATURE

a. *Context and Perspective in Knowing Nature*

Concern with material being at its most general level forms the theme of this book, and, accordingly, it is now possible to understand our title, The General Science of Nature. A scientific study of nature in its most general traits, in other words, a study of mobile being in its most universal character, forms our first problem in elaborating a logical and complete science of material things. The general science of nature is logically presumed by studies that we identify as modern natural science. Physics, chemistry, and biology, as we know them today, deal with this or that kind of mobile thing — falling bodies, the elements, organisms. These are problems of great interest and of vast importance; but they are not the problems where a truly complete scientific knowledge of nature should logically begin. Material being should be considered at its universal level before funneling downward to a concern with the various kinds of mobile things.

Many thinkers do not agree with this analysis. They would like physics,

chemistry, and biology in their modern form to be studied prior to what we have termed the general science of nature; they would make of the general science of mobile being only a synthesis of the various special knowledges attained beforehand. Some would even make the whole function of a general science of nature to be an extension of physics, chemistry, biology, and related fields.[20] But this arrangement of subject matter is contrary to the human order of learning. By disregarding this proven order and by approaching specialized knowledge of material things without a previous general science of nature, science in the modern sense is often taught and studied without attention to its own presuppositions. In this way, it is possible to lose sight, as many have done, of the very meaning of specialized, detailed, experimental, and mathematical knowledge of nature. J. Robert Oppenheimer writes, modern science "takes common sense for granted. . . ."[21] It is the area of the physical world uncovered by common sense, the precondition for all further knowledge, that our general science will analyze.

The general science of nature that Aristotle evolved does more than merely precede our more exact and detailed knowledge like a drum major leading a parade. It conditions our distinct knowledge. It gives context and perspective to all other scientific knowledge of material things. Seen within the horizon of first principles, modern empirical disciplines will be more than the practical knowledge affording a know-how for making television sets, atoms, and space satellites. Science in the modern sense will then be regarded no longer as a mere aesthetic satisfaction[22] but as something of far greater importance. Modern science would then no longer be so powerless before "the fundamental problem left open by scientific method,"[23] to quote Henry Margenau. It will no longer have to leave "our feeling of incompleteness unsatisfied," as Edwin Schroedinger has written.[24]

The truly crucial problem between science in the modern sense and science in Aristotle's sense occurs right at the beginning of our study of nature and not after modern science has been evolved. That is why so much space is being devoted here to questions preliminary to the science of nature, questions that if not properly answered will lead to a large error when our science of nature finally gets under way.

b. Permanence of *the General Science*

Since Aristotle's time, many sweeping changes have taken place in our knowledge of matter, beginning especially with the work of Kepler and

Galileo. The heliocentric theory of astronomy, as shaped into final form by Kepler, has replaced the geocentric view. Galileo's laws of falling bodies have become accepted formulas. With Newton, a universal mechanics came into being, and a short time later the march of modern chemistry began, leading at the start of the nineteenth century to the now well-established theory of atoms. In biology, great discoveries have been made concerning the structure and function of living things in health and in disease, and probably no biological theory has had such a widespread influence as the evolutionism of Darwin. Even this brief list of exploits brings us only to the beginning of our own century when brilliant new accounts of matter emerged in the form of the quantum theory and relativity mechanics. But with all of its undoubted and undying value, science in the modern sense of the term affords knowledge of a special sort concerning nature. It concerns various kinds of motion, not material being in general. It is knowledge gained by the refined techniques of measurement and experimentation. It is so detailed and exact that it is usually formulated in mathematical equations or in graphs.

Hence, no matter what parts of Aristotle's investigation of the physical world may be outmoded in this, the twentieth century, his general science of nature is in substance still acceptable in our own day. What is known in general science does not depend on instruments and experiment. It does not depend on meters and mathematics, on particle guns and high-powered telescopes, and it is not changed as they change. Though arising out of general experience — by contrast to the specialized experience which we call experiment — our general science is preinstrumental and pre-experimental knowledge simply because it is knowledge of a very general kind. Alfred North Whitehead recognized the need for a study of nature with "a generality transcending any special subject-matter."[25] That would be a good way of characterizing what we have been calling the general science of nature. At the beginning of this general science, all we need is a knowledge of logic and experience of change.

Science in the modern sense of the term depends in great part upon instruments.[26] From the study of the stars to the concern with atoms and their parts, our metrical knowledge of nature has changed as instruments have become more refined and experiment has grown more exact. But since the general science of nature does not depend on measurement and experiment, it could well develop before the rise of modern instruments, and it has survived even though our measuring instruments have furnished new and even revolutionary data in the area of specialized

study. Without previous general science, we would not be able to design instruments and arrange experiments to learn more about what we already know in preinstrumental and pre-experimental ways.[27]

Logically prior and presupposed to refined knowledge through experiment and measurement, our general science of nature is thus immune from the revolutions that have taken place in specialized knowledge. Our means of attaining this general science are no better and no worse than Aristotle's. They are in fact no different from his. The means is human reason itself, unaided by specialized and mathematical techniques, proceeding only by a logical analysis of general experience which our next chapter will explain.

c. *Certitude of the General Science*

As another way of understanding why the revolutions within our specialized knowledge of nature have nevertheless left our general science standing firm, it should be observed that the universal characteristics of mobile being, since they are most intelligible to us, are relatively easy to grasp and, as most fitted to the human intellect, are strongest in their certitude. But when we move away from the universal marks of things to more particular and refined characteristics, we enter an area that is less and less intelligible to us, even though in its own intrinsic nature it is more intelligible. As less intelligible to us, such an area is harder to study, and error can more easily enter it. As one means of preventing such error, man uses controlled experiment.

The general science of nature, even though in essence it goes back more than two thousand years, is a permanent achievement of the human intellect. Questions raised in this general science more than two millennia ago are still raised by men of today, and they are still answered at the same level of pre-experimental study and by the same means. What is motion, time, place, the infinite, etc.? Just what do we mean by these terms anyway? All such questions are at least implicitly raised prior to measurement and experiment. Measurement and experiment do not ask them; nor do they answer them. The realm of those universal principles in nature which are most intelligible to us and prior to all other considerations is usually accepted by the modern researcher in some unanalyzed form. Failure to make a proper analysis of common-sense notions has led to serious errors in the history of science, e.g., the nineteenth-century's theory of "indivisible atoms."

d. *The Concern of General Science: Mobile Being in General*

As further evidence that a general science of nature should go before special studies *of* the physical world and also as evidence that the general science is not open to the radical changes which have characterized the more special fields of inquiry, let us go again to the famous case of a falling body. If a modern physicist were pressed to ask what he means by a falling body in order to assure himself that he can define it properly and explain it to someone else, he would no doubt say something to the effect that a falling body is a body in a certain kind of motion. He would affirm, in other words, that it is a certain kind of mobile being. Such an analysis would indicate to us that mobile being is more familiar and more intelligible to us than the kinds of mobile being. The concept of mobile being would be employed to make clear and intelligible to someone else what we mean by a falling body; in other words, it would be assumed in explaining what is meant by a falling body that an inquirer knew what is meant by material or mobile being. The modern scientist can no more represent a falling body without conceiving mobile being in general than a man can think of a squirrel without thinking of an object or thing. For a complete science of nature that goes back to first principles it would only be logical to analyze mobile or material being in general, because the concept of mobile being in its universal traits is implicitly and logically presupposed to a study *of* the various kinds of mobile being. Our general knowledge of mobile being requires special and proper knowledge to complete itself and special or proper knowledge needs general science to examine its presuppositions.

Bertrand Russell recognized that no matter how technical we become in our study of nature, we must go back for a final check of all our knowledge to the familiar world that our senses directly apprehend:

> I think it may be laid down quite generally that, *in so far as* physics or common sense is verifiable, it must be capable of interpretation in terms of actual sense data alone.[28]

And John Dewey reminds us that advances in science, far from abolishing more general truth, refine and extend it:

> The history of the progress of natural science is the record of operations that refine . . . our grasp of the gross. . . .[29]

The full study of falling bodies, we have just seen, requires a study of mobile or material being at its most general level. The same analysis of

mobile being in general would have to precede the resolution of any more particular problem such as local motion in a straight line, the combinations of atoms and molecules, nutrition and growth and reproduction among living things. Rectilinear uniform motion of the sort studied by Newton, molecules, atoms, and their parts as studied in chemistry and physics, and all the life processes studied in biology are special kinds of motion of special types of material being. But in order to represent such special types, the concept of mobile being in general is logically implied and logically prior; to attain a complete science of nature, such a logically implied and logically prior realm of knowledge should be brought out into open analysis.

In order to avoid useless repetition in the analysis of types of mobile being, it is fitting that there be a portion of our study of nature devoted to a study of material being in general.[30] To such a study Aristotle devoted a whole work called the *Physics,* and to a similar task all the rest of the present book will be directed.

VII. THE SPECIAL PARTS OF NATURAL SCIENCE

a. *The Order of Special Branches*

In obedience to the order of learning, the more refined and special knowledge of material being comes after the more confused and general knowledge. The first special branch of natural science would be mechanics, the study of things in local motion, the most common and obvious type of change. Mechanics would appear as the second part of natural science because it is less general than our general science but more general than other branches of our study of nature. Because the next most common kind of change, after local motion, is qualitative or chemical change, chemistry should follow mechanics in the proper pedagogical order. Then would come the study of animate mobile being, including man, because biology concerns the least common kind of motion in our world and the motion most difficult for us to understand.[31] Set within the perspective of the general science of nature, mechanics, chemistry, and biology can be termed special brances of natural science in the Aristotelian sense of tire term, science, and all of them would have, of course, appropriate subdivisions. Examples will be given later on in this book to show how the general science and its special branches are intimately interrelated. Without these relations to a general science of

nature, science in the modern sense of the term can hardly be more than a preparation for the practical arts of engineering, medicine, etc.

b. One *Science: The General and the Particular*

According to the terms of the preceding analysis, the science of nature in the Aristotelian sense and the studies of the material world that we now identify as physics, chemistry, and biology, are not several sciences but one.[32] The first principles of material being explained by Aristotle in his *Physics* form the general part of that unified natural science. The modern studies of bodies in local motion, of chemical changes, and of living things form special parts or branches within that selfsame science. The modern studies are concerned with special kinds of material being while our general science explores material being in general. As will be seen in Chapter VIII, mathematical physics has, in a sense, a status independent of the special sciences and our general science. Yet, since it does give physical knowledge, it can also be regarded as part *of* our general science, as Chapter VIII will show.

Our next chapter will have to decide whether physics, chemistry, and biology make demonstrations and yield certitude and hence whether these modern studies have a right to the old and traditional meaning of the term science without making the term itself equivocal. Our present chapter is concerned with the relations between Aristotelian and modern science from the point of view of their objects. Do modern studies of nature have objects different from that of general science or do the objects of these modern investigations, far from being distinct and independent, form more particular parts of the same object studied at a general level by our general science? If the objects of modern physics, chemistry, and biology imply the object studied by our general science, so much so that the first cannot be represented in our minds without the second, then the Aristotelian and modern sciences of nature are not distinguished as one science from another but as general and particular levels of the same science whose object is material or mobile being.

c. *Objection: Methods Divide Sciences*

Sometimes it is argued that science in the modern sense is distinct from science in the Aristotelian sense because of the differing methods which each employs.[33] There was a time when it was fashionable to call an Aristotelian approach to nature a deductive one and the modern

approach inductive and empirical.[8] Such language is quite misleading for many reasons. Modern science in its most perfect form is deductive and Aristotle was very empirical in temper.

But differences in method, whatever they be called in language, cannot of themselves make for differences among types of sciences. Different ways of seeing things, e.g., with the unaided eye, with spectacles, with a microscope or telescope, do not change the character of sight but simply assist it in different ways to know more about its object, i.e., the colored. The basic character of medicine, to use another example, is not changed when a doctor uses chemical techniques like drugs and physical methods like surgery; medicine remains the same art in either case, and its object is health.

Method thus does not make for the primary differences between sciences. Method is blind; its character depends on the character of the object which is the primary principle for dividing scientific knowledge. Within a single science, different methods extend and enrich our knowledge of the object. They may affect our certitude in the same science. But of themselves they do not determine the nature of a science.

Finally, the study of the soul proceeds by a method different from the study of inanimate nature, and because of that method yields us some of our strongest certitudes. But St. Thomas considered this study to be a part of natural science.

d. *Another Objection: Modern Science Has a Distinct Object*

If science in the modern sense is distinct from science in the Aristotelian sense, it must have a distinct object. Is there such an object?

One of the reasons why modern science and Aristotelian science are often alleged to have distinct objects is the tendency to use the term aspect as a synonym for object. Thus science in the modern sense is often said to study matter from the aspect of its metrical character while Aristotelian science is concerned with matter from the aspect of its mobility. Since each body of knowledge studies matter from a different aspect, each has a different object.

But the truth of the matter is that an aspect is not an object or a subject in the sense in which we have used these terms during the present chapter. An aspect cannot be represented in our minds without representing that of which it is an aspect; every aspect therefore implies something underlying it and hence cannot be represented as a distinct and independent object without falsifying the real. What the scientist in

the modem sense is studying turns out to be essentially dependent upon what the Aristotelian scientist is concerned to analyze.

A few examples will show that the objects considered by modern investigators of nature are types of mobile being and that, as a result, the relation of this special knowledge to the general study of material being is not the relation of one science to another but that of particular to universal level within the same science.[35] A falling body, we have seen, is a special kind of material being which cannot be represented in our minds without the concept of material being in general; so also in the case of the moon and the tides studied by Newton; so indeed in the case of light rays, colored things, atoms, neutrons, electrons, transistors, guinea pigs, hybrid corn, fruit flies, and viruses. Some of these things are better known than others. But all of them are mobile realities.

The modern investigator is getting knowledge of the properties and causes in the material or mobile world; he is reporting to us about mobile reality, and if this is so, mobile or material being is his object. It is true that most experiments of the modern studies of nature involve instruments recording results on a scale and that most of the laws, especially in physics and chemistry, are expressed in quantitative form. But the quantitative results here always tell us about mobile being, and mobile being is thus embodied in these studies, as the object on which the results report, the subject about which predicates are made. Science in the modern sense does not have an object capable of being represented as distinct from that object we have identified as material being.

Thus to know the speed of falling bodies is to know something about a mobile thing, and just as clearly Newton's law of universal gravitation is an attempt to give us more knowledge of the mobile world than our general notions yield. Even in the case of subatomic particles, the measurements of charge and mass report on the mobile beings in question, even though they be hypothetical entities. Material being implies quantity, as Chapter VIII will argue, and a quantitative knowledge of it extends and refines the knowledge that is of a more qualitative and more general character.

A science does not change its object when it becomes more refined and detailed. Refined knowledge is simply a more particularized knowledge of what has previously been known at a universal level concerning the same object. In this respect, it may be worthwhile to quote Galileo:

> There is, in nature, perhaps nothing older than motion, concerning which the books written by philosophers are neither few nor small; nevertheless,

> I have discovered by experiment some properties of it which are worth noting and which have not hitherto been observed or demonstrated.[36]

At their face value, these words picture a man who thought he was getting at some properties of an object but not speaking about a new kind of object of investigation.

VIII. SUMMARY

This chapter has identified the object or subject of the Aristotelian science of nature as mobile being, because it is as mobile that nature is known and is a subject of scientific predication. We may consider mobile being and material being to be synonymous.

It has been further shown that in evolving the science of nature the mind, following its own natural inclination, will begin with the general and confused principles of nature and work toward the more particular and distinct. This is the direction from what is easier to what is more difficult. It is the tendency from what is more intelligible to us but less intelligible in itself to what is less intelligible to us but more intelligible in itself.

Such an order of learning requires that there be an initial treatment of mobile being in general, followed by a consideration of less universal and more distinct realities. This most universal treatment of material being is what we have called the general science of nature. Pedagogically, this general science should precede more specialized considerations like modern physics, chemistry, and biology. Such specialized fields of investigation do not have an object distinct from mobile being but give a refined, exact, and detailed knowledge of the same object that the general science of nature considers at a universal level.

REVIEW QUESTIONS

1. What is the object or subject of natural science? Explain.
2. Explain the use of the term *material being* to designate the object of natural science.
3. Why would it be wrong to say that the object of physical knowledge is the measurable? Explain.
4. Explain the pedagogical order in dealing with material and immaterial things and in dealing with the world of matter itself.
5. Prove that the human mind works from the general to the particular and from the confused to the distinct.

6. What is the reason for the term "general science of nature" and of what value is this part of natural science?
7. What is the application of this proof to the order in the study of nature?
8. Compare the general science of nature and modern sciences in regard to their objects and in regard to their pedagogical order with respect to each other.

PROBLEMS

I

Explain the following passage, using when necessary the material contained in the chapter:

". . . concerning those things which depend on matter not only according to their being but also according to their definition there is natural science which is called physics. And because everything having matter is mobile, it follows that mobile being is the subject of natural science. Natural science is about natural things, and natural things are things whose principle is nature. Moreover, nature is a principle of motion and of rest in that in which it is. Hence, natural science concerns things having in themselves a principle of motion. But because what is common ought to be examined first and separately to avoid needless repetition, by treating this common level many times, it became necessary that one work be set down in which there would be a treatment of mobile being in general. . . . This is a work called the Physics. It has for its subject mobile being taken simply. Note that I do not say mobile body because this work proves that everything mobile is a body: but no science proves its own subject. Thus it is that at the very outset of On *the Heavens,* which follows this present work, there is begun a study of *body.* Moreover, after the present work, there follow other books of natural science in which there is a treatment of species of mobile being: thus in the work On *the Fleavens,* there is a study of what is mobile according to local motion because this is the primary species of motion. In the work On Generation, there is a study of motion toward form and of the primary mobile things, namely the elements, with respect to their common changes: with respect to more particular changes there is a study in a work On Meteors. Moreover, concerning non-living compounds, there is a work On *Minerals* and concerning the living world is the work On the Soul and books that follow it."

St. Tilomas, Commentary on *the Physics of Aristotle*[37]

II

"Although there is but one road to science, that to wit, in which we proceed from things more known to things less known, from matters more manifest to matters more obscure: and universals are principally known to us, science springing by reasonings from universals to particulars: still the

comprehension of universals by the understanding is based upon the perception of individual things by the senses."

William Harvey, Anatomical Exercises on *the Generation of Animals*[38]

III

Explain how each of the following passages shows that science in the modern sense of the term presupposes a general science of nature:

"Let us then examine the kind of knowledge which is handled by exact science. If we search the examination papers in physics and natural philosophy for the more intelligible questions, we may come across one beginning something like this: 'An elephant slides down a grassy hill-side. . . The experienced candidate knows that he need not pay much attention to this; it is only put in to give an impression of realism. He reads on: 'The mass of the elephant is two tons.' Now we are getting down to business; the elephant fades out of the problem and a mass of two tons takes its place. What exactly is this two tons, the real subject-matter of the problem? It refers to some property or condition which we vaguely describe as 'ponderosity' occurring in a particular region of the external world. But we shall not get much farther that way; the nature of the external world is inscrutable, and we shall only plunge into a quagmire of indescribables. Never mind what two tons *refers* to; what is it? How has it actually entered into so definite a way into our experience? Two tons is the reading of the pointer when the elephant is placed on the weighing machine. Let us pass on. 'Tire slope of the hill is 60°.' Now the hill-side fades out of the problem and an angle of 60° takes its place. What is 60°? There is no need to struggle with mystical conceptions of direction; 60° is the reading of a plumb-line against the divisions of a protractor. Similarly for other data of the problem. The softly yielding turf on which the elephant slid is replaced by a coefficient of friction, which though perhaps not directly a pointer reading is of a kindred nature. No doubt there are more roundabout ways used in practice for determining the weights of elephants and the slopes of hills, but these are justified because it is known that they give the same results as direct pointer readings."

Arthur Eddington, *The Nature of the Physical World*[39]

IV

"At first sight, it may seem prudent to leave the consideration of facts to positive science, to let physics and chemistry busy themselves with matter, the biological and psychological sciences with life. The task of the philosopher is then clearly defined. He takes facts and laws from the scientist's hand; and whether he tries to go beyond them in order to reach their deeper causes, or whether he thinks it impossible to go further and even proves it by the analysis of scientific knowledge, in both cases he has for the facts and relations, handed over by science, the sort of respect that is

due to a final verdict. To this knowledge he adds a critique of the faculty of knowing, and also, if he thinks proper, a metaphysic; but the matter of knowledge he regards as the affair of science and not of philosophy.

"But how does he fail to see that the real result of this so-called division of labor is to mix up everything and confuse everything? The metaphysic or the critique that the philosopher has reserved for himself he has to receive, ready-made, from positive science, it being already contained in the descriptions and analyses, the whole care of which he left to the scientists. For not having wished to intervene, at the beginning, in questions of fact, he finds himself reduced, in questions of principle, to formulating purely and simply in more precise terms the unconscious and consequently inconsistent metaphysic and critique which the very attitude of science to reality marks out."

Henri Bergson, *Creative* Evolution[40]

NOTES TO CHAPTER II

1. Com. on *the Phys.,* Bk. I, les. 1, 3; On Truth, q. 14, a. 9, reply 16; Com. on *the Eth.,* Bk. I, les. 1, n. 3; *Com. on On the Heavens,* Bk. I, les. 1; cf. also Cajetan, *De Subjecto Naturalis Philosophiae* (Quebec, 1939).
2. Cf. from Chapter I, the two ways of dividing science, i.e., in terms of objective or subjective conditions.
3. For a comparison of these expressions, cf. Y. Simon, *Prévoir et Savoir* (Montreal, 1944), p. 155 ff.
4. Com. on the Phys., Bk. 1, les. 1, 3; Com. on *the Trim,* q. 2, in *The Trinity — The Unicity of the Intellect,* transi. Sr. Rose Emmanuella Brennan (St. Louis, 1946), p. 128.
5. Arthur Guiterman, "On the Vanity of Earthly Greatness," in A *New Anthology of Modern Poetry,* ed. S. Rodman (New York, 1938), p. 119. Reprinted with permission of Random House, Inc.
6. *Exposition of the Post. Anal., Bk. I,* les. 41, 7.
7. Sum. *cont. Gent.,* Bk. II, ch. 1; Com. on *the* Metereology, Bk. IV, les. 16.
8. Cf. Chapter I, p. 2.
9. La *Pensée* et le *Mouvent* (Paris, 1939), p. 9; La Durée *et Simultanéité* (Paris, 1923), p. 69.
10. Phys., Bk. I, ch. 1, 184a, 17-21; *Post. Anal.,* Bk. I, ch. 2, 71b, 34-72a, 6; Com. on the *Phys.,* Bk. I, les. 1, 7; Exposition *of the Post. Anal.,* Bk. I, les. 4, 16; Sum. cont. Gent., Bk. II, ch. 77; Com. on the *Eth., Bk.* 1, les. 4, n. 52.
11. Com. on the *Trin.,* q. 3, a. 1; transi. Sr. Rose Emmanuella Brennan, op. cit.; Com. on the *Trin.,* q. 5, a. 1, reply 9.
12. Chapter XIX, pp. 381-382.
13. Discourse on *Method,* pt. V, in Descartes: *Philosophical Writings,* N. Smith (New York: 1952), p. 148.
14. Com. on the *Phys.,* Bk. I, les. 1, 7.
15. *Exposition of the Post. Anal.,* Bk. I, les. 30, 5-6.
16. Com. on the Phys., Bk. I, les. 1, 9.
17. *Ibid.,* Bk. I, les. 1, 11.
18. Summa *Theol.,* 1, q. 85, a. 3.
19. *Ibid.,* I, q. 14, a. 6; Phys., Bk. 1, ch. 1, 184b, 24-25; Com. on the *Phys.,* Bk. I, les. 1, 6.
20. This is often the meaning attached today to the term "cosmology" as witnessed by books that pass under such a name.
21. *Science and the Common Understanding* (New York, 1953), p. 5.
22. Cf. J. Gregory, "The Aesthetic and Science," *Philosophy,* XXIV (1949), 239-247.
23. The Nature *of Physical Reality* (New York, 1950), p. 459.
24. Science *and the Human Tempera-*

ment (New York: 1938), pp. 108–109.

25. Process and *Reality* (New York, 1929), p. 15.
26. A. Whitehead, Science and *the Modern World* (New York, 1948), p. 116.
27. Cf. W. Kane, et al., Science in Synthesis (Dubuque, 1953), p. 197 ff.
28. Our *Knowledge of the External World* (New York, 1914), p. 81.
29. Art as Experience (New York, 1934), p. 29.
30. Com. on *the Phys.,* Bk. 1, les. 1, 4.
31. For the pedagogical order in our science of nature, cf. Com. on the Phys., Bk. 1, les. 1, 4; Com. on On Gen., prologue; Com. on On the Heavens, prologue; Com. on On the Senses, les. 1; Com. on On *the* Soul, Bk. I, les. 1, 1.
32. R. Nogar, "Toward a Physical Theory," *The New Scholasticism,* XXV (1951), 397-448.
33. This seems to be implicit in all who use the term scientific method as though method were the principle differentiating ancient and modern science.
34. This distinction is owed ultimately to Francis Bacon.
35. For reasoning behind this distinction cf. C. De Koninck, "Les sciences expérimentales, sont-elles distinctes de la philosophie de la nature?" Culture, V (1941), 465-476; "Introduction à l'étude de l'âme," Laval *Théologique et Philosophique,* III (1947), 9-65.
36. Dialogues Concerning Two *New Sciences* (New York, 1914), p. 190.
37. Translation from the Angeli-Potta edition, Bk. I, les. 1, nn. 3-7.
38. Anatomical Exercises on the *Generation of Animals,* "Great Books of the Western World" (Chicago, 1952), XXVIII, 332.
39. *The* Nature of the Physical World (New York, 1938), p. 244.
40. Reprinted in M. White, The Age of *Analysis* (New York, 1955), pp. 76-77. Reprinted here with permission of Henry Holt and Company.

CHAPTER III

THE SEARCH FOR NATURE'S FIRST PRINCIPLES

I. WHAT WE MUST SEEK AS THE BASIS OF OUR SCIENCE

a. *Introduction*

So far in these pages, science has been first defined and then shown to need principles because it is causal and first principles because it is certain. Within the broad threefold division of human science, the subject of our own study was found to be mobile being, that is, all reality which depends on motion in order to exist and to be understood; in addition, we saw that the mobile being which forms the subject of our science is viewed as existing in common sensible matter but not in individual sensible matter. Finally, in the effort to find first principles in material things, we saw that our science must begin at the vaguely known and general level of nature and work toward more precise and more particular notions.

The question, treated in the past chapter, of where we are to begin our science of nature is closely allied with the problem, treated in Chapter I, concerning first principles or first beginnings which are underived in nature and from which everything else in nature is derived. If it is possible to have a certain and causal knowledge of material things, these first principles must be discovered and made the starting points of our science.

b. *Denial of Nature's First Principles*

Aristotle's teacher, Plato, did not think that principles of this sort existed in nature. He concluded that man could have nothing more than opinion about the physical world. Plato's great book on nature, the Timaeus, pretended to tell no more than "a likely story"[1] about the universe.

Such a view goes back beyond Plato to Heraclitus who saw nothing but change in the world. The past is no longer, the future is not yet, and whatever is can only be in the present, Heraclitus noted. But the present, the last hope of finding the permanent and the immobile, cannot be said to be; it only passes. Thus whatever is real about our world is always in a state of flux and flow. The universe described by Heraclitus is a world of absolute change, like a giant river where no man can step into the same stream twice.[2]

Although Plato believed in another world besides our own, he adopted toward nature the view of Heraclitus that everything is in constant motion. Nothing seems permanent and fixed in our universe, and without the permanent and the fixed, certitude concerning nature must give way to mere opinion. So, at any rate, argued Plato, the teacher of Aristotle.

To challenge Plato, Aristotle wrote the first of the eight books of his Physics.[3] In order to show that scientific knowledge of nature is possible, Aristotle first had to argue that there are first principles in nature, of the type required by his logic, as explained in Chapter I, and the great achievement of Book I of the *Physics* is to show that such first principles do in fact exist in the mobile world around us.

c. Our First *Principles Must Be Certain*

As the ultimate sources or origins of all material being, the first principles in nature must have three characteristics that are of special interest to us at this point of our study. They must be known with certitude; they must be universal; and they must be physical, rather than mathematical or metaphysical in character.

Principles known only hypothetically cannot furnish the real foundations of a science. Since they are known only in a provisional way, they cannot put that order into our knowledge of things which we call certitude.[4]

The atomic theory, evolution, relativity, and other theories, however strong, concerning material things cannot furnish us with the starting points of a complete science of nature because, as theories, they are not fully proven. As theories, they fall short of certitude.

d. *First Principles Must Be Universal*

If certitude is at its maximum in our knowledge of nature only when, as previously shown, that knowledge remains vague and general, it might already be suspected that the first principles we are looking for must also be common or universal.

There are two reasons why the first principles of nature must be the most general and universal principles of mobile being. The first reason is that the science of nature purports to explain all mobile beings and hence its amplitude extends to every mobile being in the world. Since the explanatory principles we are seeking must apply to all motion, they must be the most universal or general principles in all of nature.[5]

In the second place, the first principles of nature will be universal principles because the very first scientific problem in nature as we know it concerns mobile being in general rather than this or that species of motion.[6] As observed in our last chapter, the concept of mobile being, taken simply, is logically prior to the conception of any particular kind of material thing, and mobile being in general must accordingly be studied before the analysis of various species of material things. The principles of mobile being considered at a general level will be principles that are themselves general or universal.

e. Our *First Principles Must Be Physical*

First principles in the general science of nature must not only be universal, they must also, and above all, be physical principles. Physical should be contrasted with mathematical and metaphysical as these studies have been previously identified by our three orders of abstraction.

The first principles for explaining material being must not be metaphysical since the mind, beginning its study of nature, is as yet unaware that there is any metaphysical object, an object not dependent on matter for its existence. Hence it cannot invoke a metaphysical kind of reality to explain the physical world at the outset of its study. At this point it must be strongly emphasized that physical is a synonym for natural, at least according to the terminology of this book. Physical comes from the Greek and natural from the Latin, and both of them in their origins meant having to do with birth or coming to be.[7] More of this meaning will be seen in Chapter VI, but for the present, the physical or natural world should be understood as the world of coming to be,

the world of mobile being. If physical and natural have the same meaning, it is possible to add to them a third synonymous term, the mobile. The physical or natural is the mobile.[8] Since the metaphysical is independent of motion, it is beyond the mobile. Hence metaphysical principles cannot be used for demonstrations in the science of nature or mobile being.

According to this analysis, a physical, as contrasted to metaphysical or mathematical, explanation will be an account of material or mobile things precisely as they are mobile beings. Mathematics approaches the world not in terms of motion but in terms of quantity. Although mathematical principles may be invoked later on in the science of nature when knowledge becomes more exact and detailed, the initial principles to explain nature must be strictly physical. The reasons for this view are several:

1. In the first place, the science of nature is an attempt to account *for* mobile being, and what is most characteristic of mobile being is not quantity but motion.

2. Moreover, at the beginning of our science where mobile being in general is being analyzed, our knowledge is so vague that we are unable to consider the more precise and even mathematical properties which flow from mobile being. Since quantity, which is essentially involved in any mathematical consideration, is a secondary and derived property of mobile being as an effect is secondary to its causes, mathematical principles cannot explain mobile being as such.

3. Knowledge in terms of mathematics is always more or less distinct and exact and hence is not the kind of knowledge enjoyed at the origins of our science where the object is vague and general.

4. Finally, for present purposes, it has already been shown that unless there is a physical analysis of nature preceding more particular and detailed knowledge obtained by measurement, the mind is unable to identify what it is that is being measured.

It should be noted again that the use of mathematical instruments in the science of nature is not here being denied; in fact, most of our detailed knowledge of nature will have a mathematical form. What is being proposed here is that our initial knowledge in the science of nature must be strictly physical rather than mathematical in character. Our general science must explain mobile being as mobile and not as quantified. If principles other than physical ones are necessary to explain our world, the need for such non-physical principles will have to be demonstrated..

II. DIALECTIC AND INDUCTION

a. *Inductions Are Not Blind*

We now know what we should look for in search of those first principles that would make a scientific knowledge of nature possible. These principles must be universal because they are first, and they must be physical principles, i.e., principles of motion, because it is the physical, natural, or mobile world that we are trying to explain. They must be known with certitude.

But what is to be our method of reaching such first principles? Because natural science needs them in order to get started, they cannot be reached by using natural science. In other words, as presupposed by any demonstration in natural science, they cannot be demonstrated within this science. If the first principles were learned from metaphysics or natural theology, this would mean that the mind, beginning a study of the physical world, would already know metaphysics; such a mind would have to know immobile and immaterial things before having a science of the mobile and material world.

Incapable of being previously established by any other science and incapable of being demonstrated in the science of nature itself, our first principles of material being can be known only by induction." Induction is a passage from particular to universal propositions without going through a middle term. The product of our induction will be a proposition whose subject and predicate are immediately, i.e., without a medium, connected with each other. Since its evidence does not depend on something else, a middle term, for example, the proposition that our induction will establish can be called self-evident.10

As is usual in cases of induction, the human mind dealing with the first principles of nature will not at once see the necessary connection between the subject and predicate. What may be called self-evident in the sense of not needing a middle term may nevertheless not be self-evident to us. In short, a careful investigation must be made in order to reach our first principles of nature and to make what is in reality immediately-connected fully evident to us. This investigation, preliminary to determining possible starting points in our science, is called dialectic.11

b. *Dialectic, the Logical Preliminary of Induction*

As we know from logic, the inductions made in any science do not

take place haphazardly and without a preliminary plan. Tire discovery by Walter Reed that yellow fever is carried by a mosquito was preceded by dialectical reasoning in which certain questions were asked and various answers drawn out in order to be compared by induction with experimental evidence. Such a preinductive process of raising questions and deducing the consequences of answering them in both affirmative and negative form is called dialectic. Reed, for instance, knew before he began his famous experiment concerning yellow fever that he did not have to look for the cause of the disease in sea water, the structure of palm trees, the frequency of rain, and the brilliance of sea shells. If any of these factors caused the yellow fever, he could have reasoned, then the disease would occur wherever there is sea water, palm trees, rain, or bright shells. Since there is no inductively observed relation between these things and yellow fever, Reed could have ruled out all of these possible causes; and after many other questions had been raised and answered, he could have hit upon two conclusions worth testing: either yellow fever is communicated by contact with present victims through discharges from their bodies, etc., or else it is carried from person to person by mosquito. Having reached these dialectical conclusions, Reed could check them inductively by experimental means. A person isolated from all yellow-fever victims and their discharges except for being bitten by a mosquito that had bitten a yellow-fever patient contracted the sickness. Others who made all sorts of contact with yellow-fever victims but were kept away from the suspected mosquito did not fall prey to the disease.[12]

Let us analyze the two dimensions in Reed's experiment; and in order to simplify the task, let us look at the last stages *of* his reasoning where the two testable alternatives were presented him. He could formulate his two conclusions in the following manner: If yellow fever is carried by a mosquito, then a person bitten by such a mosquito which has previously bitten a victim will contract the disease. Reed's second conclusion would run: If yellow fever is transmitted by contact, then a person who makes physical contact with a fever victim will contract the disease. Up to this point, both of tírese conclusions were purely dialectical. They are consequences deduced from the twofold question: Is yellow fever earned by a mosquito or by physical contact?

The experiment subsequent to the conclusions is the other dimension in Reed's work. This experimental phase is induction, or the passage of the mind from particular cases to a universal notion concerning all cases of the same kind.

c. *The Nature of Dialectic*

Now the questions we raise and the consequences we deduce from various possible answers to our questions are not in themselves propositions about the real world.[13] They do not become propositions about the real until the consequences are tested by induction. Until this induction takes place, dialectical propositions are provable only; by the subsequent induction they are proved.

The proposition, Yellow fever is carried by mosquitoes, expresses a fact about the real world. By contrast to such a proposition, a question and the consequences drawn out of it leave the mind only in the logical order. A proposition about reality is secured when, leaving the dialectical or logical level, we go to physical things and make an inductive test to see which consequence fits observed fact.

Demonstration deals with propositions about real causes and real effects. Dialectic, as such, deals only with logical beings.

Dialectic is a logic of questioning. A dialectician proposes possible answers to the questions he raises about any subject proposed to him. He then works out the consequences that follow from answering each question in an affirmative or negative way. This is all preliminary to experiential test. It is only provable with respect to the induction that will test which consequence is in accord with things and which answer to the initial question should be accepted. In contrast to the dialectical questioning that precedes it, induction is an operation of quite different sort. It puts the mind in correspondence with the real.

No induction in the learned world proceeds without a dialectical plan to guide it. In all such cases, induction affords a proof of the propositions that are finally accepted by the mind. To the extent that an investigator is still engaged in the dialectic preliminary to induction, his conclusions are provable but not yet proved. If the quest for nature's first principles is inductive because the principles cannot be demonstrated without using them, our induction to the principles must nevertheless be prefaced by a suitable dialectic. However, the dialectic yields only provable conclusions, which can be shown to be certain only by induction.

III. MORE COMPLICATED CASES OF DIALECTIC

Before proceeding to construct a dialectical plan of inquiry into nature's first principles, it will be helpful to continue our discussion of dialectic

itself with a view to further comparison of science in the Aristotelian sense with science in the modern sense.

a. *Pure Dialectic*

Sometimes physical and biological investigators cannot ask questions as simple and as straightforward as Walter Reed's, because the objects of their research are closed off from direct observation. In such cases, the mind makes schemes or constructs like the concept of the billiard-ball atom or the model of an ideal gas. The term "construct" was proposed by Lloyd Morgan and adopted by Karl Pearson,[14] who both write in the tradition of Immanuel Kant. These schemes or constructs conceived in the mind might well be described in Jacques Maritain's language as "beings of reason"[15] or by James B. Conant's term, "conceptual schemes."[16] As such they are useful devices to provoke questions whose answers can be checked by inductive test. Before they have been submitted to inductive verification, such constructs or schemes have only a logical status; they are pure dialectic and indeed dialectic in one of its most ingenious forms. Let us consider some examples of this pure dialectic.

In the latter half of the nineteenth century, James Clerk Maxwell, from a series of presuppositions, worked out a set of equations leading to a conclusion that electromagnetic energy, e.g., radio waves, can be sent through empty space. This theory was not confirmed for at least ten years after it was announced, indeed not until Heinrich Hertz got a series of electromagnetic waves to jump across a small opening (spark gap).[17] Hertz made an induction. He was concerned with real things. But what was the status of Maxwell's conclusion prior to this test? It was purely dialectical.

In 1916, Albert Einstein proposed his theory of general relativity which claimed that space is curved and that light rays actually travel in a curvilinear path. In 1918, a party of the Royal and Royal Astronomical Societies succeeded during an eclipse in measuring the curvature of a light ray traveling near the sun, and the measurement showed the degree of the curvature which Einstein's theory had predicted.[18] What was the status of Einstein's theory prior to the inductive evidence which favored it? It was purely dialectical.

In 1922, Louis de Broglie, impressed by the similarities between matter and light, proposed that matter has wave properties and worked out an equation for the wave length of bodies with different masses and different speeds. In 1927, Davisson and Germer measured apparent wave

properties in electrons and thus obtained some inductive evidence for the wave theory.[19] But what was de Broglie's theory prior to the induction? It was purely dialectical.

b. *Dialectical Induction*

Dialectic is like a crutch used by the human mind to achieve inductive knowledge. After such knowledge is reached, the crutch should naturally be thrown away. The proposition, The soul of man is not composed of parts, is true without intrinsic dependence on the dialectical structures used in learning this proposition for the first time, and the dialectic can later be discarded as no longer necessary. Our proposition here is certainly true.

However, it often happens that the dialectical crutch employed in making an induction cannot be thrown away to allow the induction to stand on its own feet. In most cases of this sort, we are dealing with material too small or too distant to permit direct inductive observation. We continue to look at inductive results through the dialectical device or, in Conant's term, the "conceptual scheme" we used to reach them. In interpreting Hertz's results as a series of electromagnetic waves, we are looking at fact through theory and to that extent even coloring the fact itself; one experiment and even a great number of them cannot verify completely Maxwell's hypothesis. The Hertzian waves, the Davisson-Germer experiment, and the curvature of light rays in the famous eclipse of 1918 all took the theories they tested beyond the realm of pure dialectic and made such theories more provable than they were before. But they did not dispense altogether with the dialectic. Though surely more provable as the result of successful testing, theories are not easily proved. By its very nature, dialectic is restricted to the realm of the provable; hence it always runs the risk of error. Induction may support a dialectical scheme, but until the dialectical scheme or construct can be wholly put aside, the induction cannot stand in an unqualified, unquestioned, and definitive way. An induction made within a dialectical scheme that cannot be thought away may be called a dialectical induction.

IV. MORE COMMON CASES OF DIALECTIC

a. *Mechanical Art*

A good dialectician will begin his investigation by the use of familiar

models or schemes and will have recourse to a more complicated dialectical apparatus only after the simpler ones have done their work. There are several fields in which a dialectician will find familiar materials to make temporary constructs preparing the way for the induction to nature's first principles. One of these is certainly the field *of* art, like sculpture or the making of tools.[20] The mind has such a perfect understanding of a statue or a knife that it can even bring them into existence. It is reasonable, then, to use works of art as an initial dialectical model for understanding the things in nature. Without a dialectical beginning in works of art, the mind, when turning to nature, is deprived of the services of what it knows best, namely its own products.

b. *Language*

Another rich region for dialectical models preparatory to the basic inductions concerning nature is language itself.[21] Because our language serves us so well in communicating with each other concerning the physical world, there is a prejudice that to some extent a correlation exists between the structure of our language and the structure of the things that language eventually concerns. The difference between a noun and a verb indicates some kind of distinction in things. A study of tense in grammar can aid in the understanding of time itself. If language is taken in its widest sense to include the whole of logic, the ten categories will help us to an understanding of the ten kinds of things which they indicate to us. In moving from logical or linguistic considerations to inductions concerning physical things, the mind is in general proceeding from signs to what signs signify. Many modern studies employ this essentially Aristotelian method of linguistic analysis to move toward an analysis of the real.[22]

It would be a serious mistake to assume a literal correspondence between our making of a statue and nature's making of anything, say an animal or sunlight; and it would be equally a disaster to seek in language an exact image of the structure of things. Such points of view would confuse a dialectical instrument with a real structure; they would identify the dialectical preliminary of induction with induction itself; they would conceive of our physical world entirely in man's own image and likeness. But there is an alternative between the scrapping of all dialectic on the one hand and on the other hand the mistaking of a dialectical instrument for reality itself and hence the confusion of dialectic with science. This alternative consists in using dialectic with

a view to correcting it when necessary and getting rid of it when it has served its function. It is a device extrinsic to perfect science.

When we are beginning our search for nature's first principles, there is no more obvious area to address than the things we know well enough to make and to use, our works of art. From them we may get not a replica of nature but at least some clues that can be pursued through our plan of inquiry. Art, mechanical or linguistic, may not provide inductive answers to our basic questions, but it will at least, like a good dialectical instrument, help us shape the questions themselves. That is the greatest service of art to the science of nature.

c. *Received Opinion*

A third basic source of a dialectician's raw material is made up of the various common opinions among men concerning the subject being investigated. These are provable propositions until elaborated to the point where it is possible to check them by induction. Opinions are questions or contexts for questions.[23] In every system of thought there is at least a measure of truth,[24] and well-established opinion should always be screened until truth emerges from it. The search for truth is a collective enterprise in which one generation teaches the next and in which even the errors of others, by showing us what to avoid, can be a source of profit. A good dialectician will be eager to consider the opinions of others in order to draw out their consequences, test their merits, and assimilate into his own science whatever truth he finds about matter wherever the truth may be.

Thus Aristotle, after proposing the requirements for the first principles in nature, turned to his predecessors and contemporaries to examine whether they had met such requirements and found such principles. He wanted to find what truth each set of opinions contained. He wanted to pit his own position against challenge and contradiction in order to strengthen it when possible and to change it when necessary. He thus undertook an exposition and criticism of Parmenides and Melissus, of Anaxagoras and Anaximander, of Anaximenes and Plato, of Thales and Heraclitus. All of these men propounded views on the natural universe; Aristotle deduced the consequences of each view and submitted each consequence to inductive check.[25] By examining the views of his predecessors and testing them inductively, Aristotle was able to discover the truth contained in such views, to avoid fruitless paths of inquiry, and to push the inquiry into nature's first principles further.

V. A MODERN DIALECTICAL ACCOUNT OF MOTION

a. The *Changing Character of Dialectic*

But these men and their doctrines, however fascinating they may be to the historian of ideas, are no longer rivals to general science of nature and nothing is easier than to show the absurdity of taking nature to be water or air or fire. Such views simply do not make sense in today's climate of opinion, and it would only be Aristotelian to pass them over and turn instead to the living rivals of the kind of science that Aristotle proposed. After al], the work of Copernicus and Galileo that reached its apex in the universal mechanics of Isaac Newton displaced in the minds of learned men the whole world view of Aristotle. From Newton's time down to our own, the study of the mobile world has been taken over by science in the modern sense of the term, and the general science of nature, in the Aristotelian sense of the term science, has often withdrawn into what is called the philosophy department. Many thinkers have followed the lead of Immanuel Kant, who held that there is no valid knowledge of the material world except knowledge obtained in a physics like Newton's.[26] Other writers have proposed that there are two kinds of science concerning material things — a science in the Aristotelian sense and a science in the modern sense. For all such reasons and for many others, it is not an idle task to raise the question of how a physics like Newton's relates to the first principles of material things. Does a system like Newtonian mechanics replace all other ways of knowing matter? Does it permit and even require other forms of knowledge concerning nature? If there be two bodies of knowledge about matter, how are they related to each other? A look at Newton's physics may indicate the answers to such queries.

Where Aristotle analyzed tire views of Anaxagoras and Plato as opinions that opposed or supplemented or clarified or in some manner related to his own science, it will be instructive today to replace Anaxagoras with Newton, for example, and Plato with Einstein or some other thinker relevant to our time. For the dialectical preliminaries to science are ever changing. In fifth-century Athens, the opponent of Aristotle was, for instance, Plato; so Aristotle had to apply a suitable dialectic to establish his own first principles against the claims of Platonism. In the thirteenth century, the challengers to Aristotle were

Averroës and Avicenna: and St. Thomas Aquinas, an eminent Aristotelian in his general science of nature, had to hammer out a dialectic to counteract these Arabian scientists. Today, many believe with Kant that there is no valid knowledge about the material world except what is yielded by the methods of modern physics, chemistry, and biology; and if only to justify the need in our own day for a general science of nature that logically goes before its specialized branches, it will be appropriate to glance at Newtonian mechanics to see what sort of principles it finds in things and whether such principles can give us a complete picture of matter or even a good starting point for physical science.

b. *Newton's Axiomatic Method*

Like any seeker after principles, Newton will be found to be employing a dialectic and aiming at induction. His method is similar to the one already explained in this chapter and to be applied in the next one. Whatever criticisms are made here of his own dialectical apparatus and whatever limitations may be placed on his mechanics are intended only to test whether he has attained to principles from which everything mobile is derived and which themselves are not derived from anything in nature. Such principles, we have seen, must be certain and universa] because of their character as first principles; they must be physical or natural because they are starting points within the mobile world.

Let us listen, then, as Isaac Newton propounds his first axiom or law of motion, the truly basic principle of his whole system of physics:

> Every body continues in its state of rest, or of uniform motion in a right [straight] line, unless it is compelled to change that state by forces impressed thereon.
>
> Projectiles continue in their motions, so far as they are not retarded by the resistance of the air, or impelled downwards by the force of gravity. A top, whose parts by their cohesion are continually drawn aside from rectilinear motions, does not cease its rotation, otherwise than as it is retarded by the air. The greater bodies of the planets and comets, meeting with less resistance in freer spaces, preserve their motions both progressive and circular for a much longer time.[27]

Newton calls this principle, on which his whole system rests, an axiom or law. Such a use of words would tend to suggest that Newton is using an axiomatic or postulational approach to a subject matter. In this method, which dates back at least as far as Euclid, results are deduced from a set of propositions and, if we are dealing with a physical system, such results are compared, by means of induction, with ex-

perience. A big question in evaluating such axiomatic systems is whether the original postulates are certain or only arbitrary, whether the conclusions are true in an unqualified way or only relatively to the postulates themselves, and hence whether the system is dialectical or truly scientific.

Besides a general question that must be asked of any postulational system of science, several more specific questions ought to be raised concerning Newton's principle. Is the principle in question certain? Is it truly physical? Is it universal? If any of these questions cannot be answered in the affirmative, then with all due regard for what can be done in using a physics like Newton's, we must look elsewhere to find the certain, physical, and universal beginnings of our natural science.

c. *Newton and Dialectic*

Inspection of Newton's axiom will show that it is an idealization. In the literal meaning of its terms, the axiom represents an object that can exist only in an ideal or logical order. For there is no such thing as a force-free motion in the physical world; all movement is subjected at least to the force of friction and does not have the isolation which the law would require.[28] Newton is therefore depicting what would happen in an idealized motion, a motion isolated from everything else in the universe and even from its own inner forces of friction. Such motion can "exist" only in the ideal or logical, hence dialectical, order.

The motion described in Newton's first law when the law is taken literally does not have a truly real existence. It is a dialectical construct or, in Conant's term, "a conceptual scheme."

The paragraph which follows the enunciation of the law of inertia cannot be considered a proof for the axiom. If taken as proof this material would beg the question because it assumes the law.[29] Newton is here explaining what his law means. As a good teacher, he is bringing up concrete examples of a general rule that he wants us to understand, but each example is a dialectical idealization like the law itself. Each example assumes the law, restating it in more concrete form in order to render it more meaningful. But the induction made as the result of such examples is dialectically qualified because the idealized motion in question does not really exist. It is a dialectical induction.

Physical reality may well approximate the dialectical ideal which Newton proposes.[30] Our universe may look to be so closely patterned after the law of inertia that Newton could construct what was once believed to be a truly universal mechanics, describing motions not only

on earth but throughout the whole solar system. But even when considered sound in principle, Newtonian mechanics could have been at most a good approximation to physical reality. What is approximately true in the sense of Newton's postulate is true only in a relative or dialectical way and not absolutely and without question.

Newton's first principle can claim inductive support, but a dialectical apparatus remains to qualify the law of inertia even when inductively tested, so that it can be no more than a more or less strongly provable principle. Dialectic is mingled with the resulting induction. If the law of inertia is a dialectical idealization, all conclusions drawn from it are qualified; they are true with respect to a postulate and not true in an unqualified sense. Newton therefore leaves us with a starting point for the study of nature which is at most provable and not proved. It does not fulfill one of our three requirements for a first principle, i.e., certitude.

d. *Newton and Mobile Being*

Apart from the decision that Newton's law of motion is dialectical at least in part, there are several other reservations that must be made concerning principles of this type as starting points for the study of nature. However, before proceeding further, it should again be emphasized that we are not here denying the value of Newtonian mechanics and other similar systems of physics and chemistry and biology. The only issue is whether or not Newtonian mechanics or other similar systems can serve as starting points for an investigation of nature that is scientific in the sense of our first chapter; and, if they cannot serve as starting points, how they relate to the general science of nature.

In addition to being dialectical, Newton's axiom or law of motion regards nature from a viewpoint that is not strictly physical but highly mathematical in color and tone. As the title of his masterwork would indicate, Newton is concerned with The Mathematical Principles of Natural Philosophy, and in his first law or axiom,[31] commonly called the law of inertia, he sets out to practice what his title preaches. Let us read the law again: Motion in a straight line introduces mathematics; uniform motion also brings in geometry since uniformity involves, as Galileo remarked, covering equal distances in equal intervals of time.[32] Distance, equality, and interval are all of a quantitative rather than an essentially mobile character. The analysis of body, force, and state would complete the roster of basic concepts in Newton's first law and would show that every one of them is predominantly mathematical in char-

acter. But without going into such detail, enough has been said already to show that Newton's axiom is not strictly physical; it is not a principle of the natural or mobile as such. Hence, whatever Newton may be doing in a positive way, he does not deal with first physical principles that apply to motion simply as motion rather than to motion as quantified. And we have seen that to study nature we must first study the mobile and only later the metrical.

e. *Newton and Universality*

This brings up a third criticism of Newton's law as the starting point for a scientific knowledge of nature. His law bears upon a particular kind of mobile being — a body undergoing local motion and indeed local motion of a uniform rectilinear character — and not upon mobile being as such.

According to the order of learning outlined previously, the mind by a logic that is at least implicit becomes aware of mobile being in general prior to an awareness of its types. In a similar way, the scientific treatment of uniform local motion belongs only after a consideration of what it means to move locally; in turn, the consideration of mobile being in local motion comes only after an account of mobile being in general.

There are at least three reservations on Newtonian mechanics as a starting point for a certain knowledge of nature through its causes, and if other and later systems of mechanics are analyzed, the threefold hesitation will be found in an even more emphatic form. The axiom or law of motion on which Newton's mechanics rests is a dialectical induction; it is mathematical; and finally it plunges into a treatment of a certain type of mobile being without first studying mobile being in general where a perspective can be established for all other natural knowledge.

VI. DIALECTIC AND NATURE'S FIRST PRINCIPLES

a. *Our Reason for Considering Newton*

Newton has been considered here as a sample of the modern investigations of nature in order to compare his principles with the first principles that a general science of nature would require. The general method

of Newton is the same as that of any other mind seeking principles — a dialectical construct followed by induction. It is essentially the same method that Aristotle applied at a much more fundamental level, as we shall see in our next chapter. Newton and other modern scientists employ the dialectical method in finer form; but as the subject of general and special scientific knowledge of nature was found to be the same, only considered by each on different levels, the general and the specific, so here it may be argued that Newton employs the same dialectical method as Aristotle and, like Aristotle, seeks an induction to principle. But Aristotle can in the end abandon his dialectic; modern science in general cannot. Hence in method as well as in object, there is but one science of the natural world. Our concern with Newton brings out the need for a science of nature even more fundamental than that which his mechanics provides us, fundamental in being certain, physical, and universal.

Newton begins with the derivative and the secondary, not with the underived and the primary. The science we are seeking, i.e., the certain knowledge of nature in terms of causes, must begin prior to the point where Newton actually starts, and it must likewise be able to dispense with the dialectical devices it employs as preliminaries to induction. This prior physics which examines mobile being as mobile being may not materially change the law of inertia; but it will, we can expect, make a difference in the perspective in which the law is seen and hence provide a framework for evaluating what Newton has done, even making his great work to be greater.

b. *Clues From Newton*

From another angle Newton's axiom, although it does not reveal first principles to the mind, reflects an implicit and shadowy possession of these principles. For Newton in one way or another brings home to us the notion that movement involves difference or duality of some kind. There is opposition or duality, for instance, between the tendency of a body to preserve its uniform motion and the impressed forces which tend to slow it down; between the movement of a projectile and the resistance of the air; between the spinning motion of a top and the retarding force represented by the atmosphere. Newton shows respect for the fact that motion involves some kind of duality, and to this extent his principle implies what is called contrariety. Motion, as the next chapter will argue, always involves opposition or contrariety.

VII. SUMMARY AND CONCLUSION

In the present chapter the dialectical method for reaching nature's first principles has been outlined, and Newton's axiom of motion tested to see whether it can form the kind of principle we are after. The law or axiom turned out to be too mathematical and too specific to be a basis for the study of material being in general. Above all, it retains, like many an explanation in modern science, a dialectical character; it is a dialectical induction. Whereas at least in certain cases an Aristotelian can abandon his dialectical scheme for reaching principles, a modern scientist often cannot.

But Newton's law does indicate to us in its own way that motion always involves opposition or duality, and this provides a clue to further investigation that the next chapter will begin.

REVIEW QUESTIONS

1. What was the occasion of Book I of Aristotle's *Physics?*
2. Name and explain three characteristics of the first principles of nature.
3. Explain why dialectic is called a preliminary to induction.
4. Does dialectic prove an inductive conclusion? Explain.
5. Explain the use of dialectic and induction in search of the first principles of nature.
6. Why is Walter Reed's work an illustration of dialectic and induction?
7. Explain dialectic as a logic of questioning.
8. Explain pure dialectic, using examples.
9. What is the difference between induction, dialectic, and dialectical induction?
10. Why are mechanical art, language, and received opinion good fields for dialectic?
11. What is the danger of using art and language to find principles of reality?
12. Explain how and why a dialectic is ever changing.
13. State Newton's law and discuss it as a possible starting point for the study of nature in the light of our three requirements for first principles.
14. What can be learned in a positive way from Newton concerning the need for a prior physics and also concerning possible principles to look for in that physics?

PROBLEMS

I

Apply to the argument in the present chapter the statements in the following passages:

"It [treatise on dialectic] has a further use in relation to the ultimate bases of the principles used in the several sciences. For it is impossible to discuss them at all from the principles proper to the particular science in hand, seeing that the principles are the prius of everything else: it is through the opinions generally held on the particular points that these have to be discussed, and this task belongs properly, or most appropriately, to dialectic: for dialectic is a process of criticism wherein lies the path to the principles of all inquiries."

Aristotle, *The Topics*[33]

"*The* dialectician . . . proceeds to consider [all things] from the viewpoint of logical relations which are extraneous to the nature of things. And thus dialectic is said to be tentative, because it is proper to the tentative to proceed from extraneous principles."

St. Thomas, Commentary on *the Metaphysics*[34]

II

Compare two or more of the following passages with each other and with the material covered in the present chapter:

"After the scientist has set up a simple formula, he must derive from it observable facts. Then he must check the consequences, to see if they really are in agreement with observation. Thus the work of the scientist consists of three parts:

"1. Setting up principles.

"2. Making logical conclusions from these principles in order to derive observable facts about them.

"3. Experimental checking of these observable facts. These three parts make use of three different abilities of the human mind. Experimental checking makes use of the ability to observe, to record sense impressions; the second part requires logical thinking, but how do we get the principles in the first part? This is an extremely controversial point."

Philipp Frank, *Philosophy of Science*[35]

"As a first approximation, we may say that science emerges from the other progressive activities of man to the extent that new concepts arise from experiments and observations, and the new concepts in turn lead to further experiments and observations. The case histories of the last three hundred years show examples of fruitful and fruitless concepts. The texture of modern science is the result of the interweaving of the fruitful concepts. The test of any new idea is therefore not only its success in correlating the then-known facts but much more its success or failure in stimulating further experimentation or observation which in turn is fruitful. This dynamic quality of science viewed not as a practical undertaking but as development of conceptual schemes seems to me to be close to the heart of the best definition."

James B. Conant, On *Understanding Science*[36]

"I see on the one side the totality of sense-experiences, and, on the other, the totality of the concepts and propositions which are laid down in books. The relations between the concepts and propositions among themselves and each other are of a logical nature, and the business of logical thinking is strictly limited to the achievement of the connection between concepts and propositions among each other according to firmly laid down rules, which are the concern of logic. The concepts and propositions get 'meaning,' viz., 'content,' only through their connection with sense-experiences. The connection of the latter with the former is purely intuitive, not itself of a logical nature. The degree of certainty with which this connection, viz., intuitive combination can be undertaken, and nothing else, differentiates empty phantasy from scientific 'truth.' The system of concepts is a creation of man together with the rules of syntax, which constitute the structure of the conceptual systems. Although the conceptual systems are logically entirely arbitrary, they are bound by the aim to permit the most nearly possible certain (intuitive) and complete co-ordination with the totality of sense-experiences; and secondly, they aim at greatest possible sparsity of their logically independent elements (basic concepts and axioms), i.e., undefined concepts and underived (postulated) propositions."

Albert Einstein, Autobiographical Notes[87]

NOTES TO CHAPTER II!

1. *The Timaeus,* transi. B. Jowett, 21. The Dialogues of Plato (New York, 1937), II, 7. Cf. the comparison of this approach with modern "cosmologies" in E. Gilson, *The Choir of Muses* (New York, 1953), p. 10.
2. Cf. *The Cratylus,* transi, cit., 402; I, 191.
3. C. Taylor, "The Relation Between Book I and II of the Physics," Laval Théologique et Philosophique, VII (1941), 150-158.
4. On *Truth,* q. 11, a. 1, reply 13; q. II, a. 1, reply 17; q. 12, a. 1.
5. Com. on the *Physics,* Bk. I, les. 1, 6.
6. Cf. supra, p. 38.
7. A. Taylor, Aristotle (New York, 1955), p. 63.
8. *Ibid.;* cf. the definition of nature in Chapter VII.
9. Com. on the Phys., Bk. VII, les. 1, 2 ff.
10. On Truth, q. 14, a. 1.
11. Aristotle speaks of dialectic as a "line of inquiry." The *Topics,* I, ch. 1, 100, a. 18; cf. my treatment of dialectic in The Elements of Logic (Milwaukee, 1957), chs. 23, 28, 29, 30; cf. especially, "Dialectic in Philosophical Inquiry" (first paper) by O. Bird, (second paper) by Sr. Rose Emmanuella Brennan, Proc. Amer. Cath. Phil. Assoc. XXIX (1955), 234-258.
12. For a popular account of the experiment, cf. P. de Kruif, *Microbe Hunters* (New York, 1926), pp. 311-333.
13. Com. on *the Met.,* Bk. IV, les. 4, n. 574; Bk. XI, les. 3, n. 2204.
14. K. Pearson, *The Grammar of Science,* Reprint (New York, 1957), p. 41 and note.
15. Les Degrés du Savoir, p. 273 ff; The *Philosophy of Nature* (New York, 1951), p. 70.
16. On *Understanding Science* (New Haven, 1947), *passim.*
17. E. Whittaker, History of the *Theories of Ether and Electricity* (New York, 1951), p. 319 ff.
18. A. Sommerfeld, "To Einstein's 70th Birthday," *Albert Einstein: Philosopher-Scientist.* ed. P. Schilpp (Evanston, Ill., 1949), p. 101.
19. L. de Broglie, *Matière et Lumière* (Paris, 1937), p. 28.
20. Çf. the example of the making of a

statue in *Phys.,* Bk. I, ch. 7, 191a, 8-10; Com. on the Phys., Bk. I, les. 12, 11-12.

21. Cf. such use of language in Phys., Bk. I, ch. 7, 189b, *33 ff.; Com. on the Phys.,* Bk. 1, les. 12, 4 ff.
22. Cf. M. Thompson, "On Category Differences," *The Philosophical Review,* LXVI (1957), 486-508; A. Reck, "Substance, Language, and Symbolic Logic," The Modern *Schoolman,* XXXV (1958), 155-171.
23. For the sociological references of dialectic, cf. Y. Simon, et al., *The Material Logic of John of St. Thomas* (Chicago, 1955), Introduction, p. XVI.
24. Phys., Bk. I, ch. 5, 188a, 18-20; Com. on the Phys., Bk. I, les. 10, n. 5.
25. Phys, Bk. I, ch. 2-4.
26. *The Critique* of Pure Reason, transi. N. Smith (London, 1929), p. 20.
27. *The Mathematical Principles of Natural Philosophy,* transi. A. Motte, rev. F. Cajori (Berkeley, 1947), p. 13.
28. Cf. W. Kane, *et al., Science in Synthesis* (Dubuque, 1953), p. 38 ff, for a discussion of Newton's law as a principle for natural science.
29. Cf. A. Eddington's poignant criticism of the law in The Nature of the Physical World (New York, 1938), p. 127.
30. V. Lenzen is content to let physics rest on a system of successive approximations. Cf. The Nature of Physical *Theory* (New York, 1931).
31. That Newton conceived his first law as mathematical is shown by A. Wallace, "Newtonian Antinomies Against the *Prima Via," The Thomist,* XIX (1956), 151-192.
32. Dialogues Concerning Two New *Sciences* (New York, 1914), p. 191.
33. Bk. I, ch. 2, 101a, 36-101b, 4.
34. Bk. IV, les. 1; Com. on the Met, Bk. IV, les. 4, n. 574.
35. The *Philosophy of Science* (New York, 1957), p. 43. Reprinted with permission of Prentice-Hall, Inc.
36. On *Understanding Science (New* Haven, 1947), p. 24. Reprinted with permission of Yale University Press.
37. *Albert Einstein — Philosopher-Scientist* (Evanston, III, 1949), pp. 11-12. Reprinted with permission of Northwestern University Press.

CHAPTER IV

TWO FIRST CONTRARIES AND THEIR SUBJECT

I. ARISTOTLE'S DIALECTICAL PLAN OF INQUIRY

a. *Aristotle and the Modern Dialectician*

> The principles [of nature] in question must be either (a) one or (b) more than one.
>
> If (a) one, it must be either (i) motionless, as Parmenides and Melissus assert, or (ii) in motion, as the physicists hold, some declaring air to be the first principle, others water.
>
> If (b) more than one, then either (i) a finite or (ii) an infinite plurality. If (i) finite (but more than one), then either two or three or four or some other number. If (ii) infinite, then either, as Democritus believed, one in kind, but differing in shape or form; or different in kind and even contrary.

This is the opening passage of the highly important section in his *Physics*[1] where Aristotle sets out to find the first principles of nature. The quotation is given here not with a view to making a close analysis of its contents but only as an example of Aristotle's method. Aristotle follows up the division we have cited by analyzing all of the alternatives he mentions. He draws out, like a good dialectician, the consequences of each position until he reaches propositions that can be checked inductively,[2] and in this fashion, he finally reaches the genuine first principles of nature that we ourselves will begin to search out in the present chapter.

Before beginning the dialectical syllogisms and the subsequent induction to nature's first principles, it might be useful to compare the passage we have quoted with the work of science in its modern sense.

As exemplified by Newton[3] and as explained by Einstein[4] and Frank, the "work of the [modern] scientist consists of three parts:

"1. Setting up principles.

"2. Making logical conclusions from these principles in order to derive observable facts about them.

"3. Experimental checking of these observable facts."[5]

Because he is working at a general rather than special level, Aristotle uses common experience rather than deliberate experiment in the post-dialectical and inductive phase of his work. But if we take "principle" in Frank's language to be a logical principle, then, from a logical point of view Aristotle's method in quest of first principles is the same as Newton's or Einstein's approach to the more particular and distinct levels which their respective stages of research permit and even demand.

b. *Rigorous Logic Is Possible at This Point*

The first thing to be noted about Aristotle's outline is the rigorous character of each division. He is not employing a so-called "cut-and-try" method, like that begun by Kepler and continued through the rest of modern physics. In the opening statement of our quoted passage, it is claimed that the principles of nature are one or more than one. Such a division is complete; and the members are opposed to each ether in an exclusive way. Anyone possessing the liberal art of logic, which our science of nature presupposes,[6] could make and follow this division. So also in the case of the various subdivisions.

What does Aristotle do with the various alternatives he proposes? Let us consider only the first one (a, i), namely, that the principle of nature is one and motionless as held by Parmenides and Melissus. If this is true, Aristotle argues in his dialectic, there would be no motion; for motion always involves at least two principles, the old and the new. In the dialectical argument just summarized, Aristotle thus draws out the views of Parmenides and Melissus (a, i) until he reaches the dialectical conclusion that motion on their supposition does not occur. But the inductive check of this conclusion reveals that motion does occur. Hence, the conclusion reached from the supposition, in (a, i), namely, that the principle of nature is one and motionless, is false; therefore the premise leading to it must be false also. Hence, the first possibility, i.e., that the principle of motion is one and motionless, is eliminated.

Aristotle then continues through his list until he concludes dialectically and establishes inductively that there are three and only three first principles in material things. We are going to pick up his tracks again later in this chapter and try to follow him to the positive conclusion he reaches concerning nature's principles; but since space will not permit a reconstruction of the whole argument based upon the above quotation from the *Physics,* it would be a valuable private exercise to make a dialectical development and an inductive test of all the possible alternatives mentioned by Aristotle. And it would certainly be most instructive to read Aristotle's own dialectic[7] or to follow it in St. Thomas' Commentary.[8]

c. *Aristotle and the Modern Cut-and-Try Method*

Tire simple and certain procedure of Aristotle in quest of the first principles of nature is seldom possible in human thought. Aristotle was working on a kind of reality that can be experienced head-on, that is, open to direct observation, and that all further investigation presupposes. At the outset of his examination, the student of material being can have a deliberate and carefully prepared plan like that which Aristotle preached and practiced; many other discoveries in the physical universe, however, are based on hunches and guesses, since the material under investigation is not open to direct view and conclusions cannot be checked by sufficiently evident inductions. In order to gain truly distinct and particular knowledge of such matter, it is thus necessary to use a "cut-and-try" method popular since Kepler — conceiving an hypothesis, deducing its consequences, and testing the results inductively; and if the hypothesis fails, a new one is conceived and the dialectical deductions are started all over again until a theory is established as having a high degree of provability by experiment. John Dewey summarized this process in describing the five stages of the act of thought:[9]

> Upon examination each instance, [among examples of problem solving] reveals, more or less clearly, five logically distinct steps: (i) a felt difficulty; (ii) its location and definition; (in) suggestion of possible solution; (iv) development by reasoning of the bearings of the suggestion; (v) further observation and experiment leading to its acceptance or rejection; that is the conclusion of belief or disbelief.

II. CONTRARIETY OF NATURE'S PRINCIPLES

a. *Intimation of Contrariety*

In going through his file of opinions to screen out the truth in any or all of them, Aristotle claimed that the ancients who investigated the mobile world in a truly physical or natural way agreed that there are contraries in nature.[10] A similar verdict can be reached concerning "received opinion" from modern studies of the mobile world. All successful theories about matter recognize that motion always involves some kind of opposites which, in the broad sense of the word at least, are contrary differences. In chemistry, for example, an opposition or difference is posited between atoms and the spaces between them. In electricity, there is positive and negative charge; in magnetism, the north and south poles are apparent; in elastic substances, stress is opposed to strain. Moreover, an elementary understanding of energy requires the distinction between the opposites, mass and velocity; force is also resolved into two components, mass and acceleration. In optics, the color of a substance depends on the distinction between what is reflected and what is absorbed.

Such a catalogue could be continued into the more complicated physical systems of quantum mechanics and relativity theory. Here also careful students of nature will be found to agree, implicitly at least, that motion involves opposition, difference, duality. In more technical language, motion involves contrariety.

b. *The Definition of Contrariety*

Contrariety is a technical notion drawn from logic, which the science of nature presupposes. Our quest for nature's first principles, as a dialectical enterprise, begins in the logical order. Using "received opinions" as a dialectical structure, the mind reaches the tentative conclusion that the first principles of nature must be contraries, and induction must put this dialectical conclusion to a real test. But what do we mean by contrary?

Things contrary to each other are, in the first place, different from each other. But contrariety says more than what we ordinarily mean by difference. Contraries are differences within the same genus.[11] Blue and red, differences within the genus of the colored, are contraries; being in Baltimore and being in Washington, differences within the

genus of where, are likewise contraries. But blue and being in Baltimore are not contraries. Though opposites, they are not in the same genus; they are unrelated by anything save an accidental connection.

c. *The Inductive Test of a Dialectical Conclusion*

It is a matter of common observation that motion involves contrariety. First of all, it requires differences or, as Plato put it, duality. Compared to what or where or how a thing was at the start of a motion, it is different at the end. Experience proves that this is so.

Experience also reveals that the differences which motion involves are contrary differences. This is a certain truth established by induction. Motion in the physical world is not a random, haphazard affair. There is an order in motion, which the mind discovers through induction. That is, there is a certain limit to what this or that thing can become because not everything can come from anything.[12] Although the blue can become the red, and what is in Washington can become present in Baltimore, the red cannot change to being in Washington or the blue to presence in Baltimore.[13]

Of course a man, going to Baltimore in midsummer, may become sunburned along the way. But there are two motions involved here, and the connection between them is accidental. One motion — from being in Washington to being in Baltimore — is local motion; the other movement — from being not red to being red — is in the order of the qualified. The two motions are related in only an accidental fashion; were there an essential relation between going to Baltimore and becoming red, everyone traveling to Baltimore would become red. Each of the two accidentally related motions has its own set of contraries within the respective genus in which the change occurs, the where and the qualified.

What things may become, as a result of motion, is limited to differences within that genus or category where change occurs. Such differences within the same genus are contraries.

iii. FIRST PRINCIPLES AKE FIRST CONTRARIES

a. *Substantial and Accidental Change*

The first principles of mobile being are not just any kind of contraries, like red and blue or like being in Baltimore and being in Washington.

They must be first contraries, i.e., contraries which are not derived from other contraries. This means that they must be contraries in the genus of substance.[11] For substance is the fundamental material or mobile being in our world, and the contraries in changes of substance are the fundamental principles *of* matter. Substance is fundamental because accidents depend on it.

Before agreeing on names for the contraries in substantial change corresponding to blue and red in qualitative change, it is necessary in the first place to insist on the essential difference between substantial change and accidental change and hence on the essential difference in their contraries. In substantial change, a whole mobile or material being is changed into another mobile being; in accidental change, a material thing remains essentially what it was but is changed according to some modification like quality, quantity, or place.

Examples of substantial change would be the burning of wood which yields ashes, the death of an animal which leaves only inanimate chemicals, and the weathering of iron which produces a new kind of thing called rust. Accidental changes, by comparison, would be the growth of an animal with the animal remaining the same throughout the process or the transportation of the same wood or same iron from one place to another. The first kind of change is fundamental and the second is only superficial. We could employ the terms fundamental change in place of substantial change and superficial change in place of accidental change. But substance and accident are old categories in our Western tradition and are known to us also from logic.[15] So with the understanding that the substantial is the fundamental and the accidental the superficial, we can continue to contrast substantial and accidental change.

In substantial change, a whole thing changes, whereas in accidental change the thing in question remains itself and simply takes on a new attribute.

Since accidents depend on substance, the contraries in accidental change are dependent and hence derived principles; on the other hand the contraries in substantial change will be the underived and hence first principles sufficient to make possible a science of nature.[10] If substantial change takes place, the contraries which it involves, corresponding to the blue and the red in the qualified, will be the principles in nature from which everything natural is derived and which themselves are not derived within nature.

Substantial change is here contrasted with accidental change, and it

is being argued that the contraries in substance, the first genus, are first contraries in mobile being and hence the first principles of nature. There might, however, be room to argue that the distinction we are now making between changes according to substance and changes according to accident is really out of place at this general level of investigation,17 that it depends on the findings of modern physics and chemistry, and that it should therefore be put off until a later stage of our inquiry. To discuss substantial change, is it not necessary to consult atomic physics with its theories of subatomic particles, binding energies, fission and fusion, etc.?

In answer to this objection, it should be emphasized first that our present concern is only to show that there is a difference between substantial and accidental change, not to explore what this difference is in the clear and particular manner made possible by modern physics and chemistry.

Second, a realization of the difference between the two changes in question is a matter of general knowledge. The distinction between substantial and accidental coming-to-be is basic in our study of nature and is presupposed to any further knowledge of motion and of mobile being. The mind, even in its vague and general notions of the physical world, thinks that there is an essential difference between, say, the burning of wood and wood's change of position; between the growth of a cat and the death of a cat; between the reddening of an apple and the digestion of an apple in some animal or other. The mind, let us repeat, naturally sees an essential distinction between substantial and accidental changes. And it sees this distinction quite early in any analysis of nature.

Third, since all our knowledge of nature is derived from change, the distinction between substantial and accidental change is the basis for that distinction, so important in all further knowledge, between what is essential and what is non-essential to the things that we experience. How do we get our first vague inklings of what is essential and what is non-essential to wood except to see how far the wood can be altered without ceasing to be wood? The first general knowledge of what is essentially living as opposed to non-living occurs when living things no longer change in mere size or color or position but when they die. The difference between what is essential and what is non-essential to the things of our experience, e.g., wood, cats, iron, etc., is in its final analysis a matter of distinguishing between substantial and accidental change; that is why this distinction can and must be made quite early

in our study of nature and not in the particular and specialized branches of our science which depend on the distinction between the essential and non-essential. Even to ask whether this or that change, as studied in atomic physics, is fundamental to a thing or merely a superficial modification, shows that the human mind recognizes an area of fundamental or substantial change by contrast to superficial or accidental modification.

Fourth, language shows that we think of some things, e.g., wood, paper, or living realities, as coming-to-be and passing away (substantial change) in contrast to things that remain what they are and simply acquire a new attribute like a new shape or size (accidental change). Thus the difference between substantial and accidental change is a basic distinction in our common language where our first thoughts about nature are embedded.

it may be that our dialectical defense of the distinction between substantial and accidental change seems unduly complicated. It is not the initial knowledge of this distinction which is complicated but rather any attempt to define and defend anything so fundamental. The complexity is on the part of our dialectic; not on the part of the distinction which the dialectic is upholding.

Substance is the first and fundamental mobile being in our world, and contraries in changes that take place within this genus are the first and fundamental contraries. In contrast to the derived and dependent contraries in accidental change, contraries that substance embodies can be best designated as possession (habitus) and privation.[115] These are contraries only in a wide sense of the word,[19] and by an extension of the meaning of contrariety as found among accidents, e.g., red and blue or loud and soft. Possession and privation, as opposites in the genus of substance, contraries in the wide sense of the term, and first principles of mobile being must now be explained.

b. *The Contraries in Substantial Change*

Privation should be set in contrast first of all with negation. Negation is any absence of an attribute, e.g., the absence of sight (blindness) in the case of a stone. Privation, on the other hand, means something more. It designates the lack of a quality in a subject capable of owning that quality.[20] Tirus, the lack of sight, a simple negation in the case of a stone, is a privation for man or a dog or a horse. Privation is a negation of something in a subject competent to have that something.

Privation and possession (habitus) are the fundamental kinds of opposites. Contraries only in a wide sense of the word, they might be better presented as principles of contrariety[21] since they form the basic opposition which exists in nature. As opposites within every substantial change, possession and privation are the fundamental principles in our mobile world. Rusted iron possesses a certain character that the natural world was deprived of before. The cadaver of a dog has (possession) a reality that before it did not have (privation). What formerly was wood (possession) is no longer wood after burning or rotting (privation). In all such changes, a thing does not change only according to one or more of its attributes; but the whole thing changes and the change itself involves the opposition between possession and privation.

So far in our dialectical quest for principles, it has been shown that all careful students of nature have remarked on the differences or oppositions found in all motion. But many of them, including modern physical and biological researchers, fail to go all the way to the first differences or first contraries which are revealed by substantial change[22] and which may be described for the moment as privation and possession. Our induction has shown that there is substantial or fundamental change in nature as opposed to accidental or superficial modification; and applied to substantial change, induction has likewise manifested possession and privation as the first principles of nature because they are opposites in the first genus, namely, in substance.

IV. THE SUBJECT OF THE FIRST CONTRARIES

a. *Accidental Change Requires a Subject*

Our discussion has taken a short cut through the outline quoted from Aristotle at the beginning of this chapter, and the conclusion has been reached that the first principles of material being are at least two: possession and privation. Every motion in the accidental order requires contraries, and since accidents depend on substance, all mobile being depends upon possession and privation in the substantial order. Tírese opposites, because they are in the substantial order, are first contraries even though contrariety is used here in a wide sense of the word.[23] Such first contraries are first principles of mobile being.

But contraries, whether secondary as in the case of accidental modification, or primary as in the case of substantial change, are not enough

to account for motion. There must be a subject competent to possess at the end of the process what it lacked before (privation).[24] A look again at some common examples will supply inductive evidence for this conclusion. In changes of color, like that of an apple, greenness does not become redness, and in our example of local motion between Baltimore and Washington, one place does not become another. That which was green becomes that which is red; a man, e.g., who was in Baltimore is now a man who is in Washington. As shown by these examples, contraries in motion require a common subject in which they succeed each other.

b. *Substantial Change Requires a First Subject*

Even in the case of substantial change, possession and privation, which are first contraries and first principles in nature, require a subject. For like contraries in the accidental order, possession and privation can succeed each other, as they do, only if there is a common subject. If nothing from the old substance abided in the new, annihilation and creation would occur.

Using from our science of logic the notion of contraries,[25] our analysis has led to the induction that motion always involves a subject and two contraries; in the substantial order this first subject is called primary matter, and the two first contraries are possession and privation. Primary matter and two contraries which are all evident in substantial change are the three first principles of mobile being, underived in nature and the source of everything in our physical world.

Our argument, following Aristotle's alternatives at the beginning of this chapter, could go on to show the inductive conclusion that no change essentially involves more than one subject and more than two contraries and that there are not more than three first principles in nature. If there were more than one subject or more than two contraries, there would be more than one change, as in the case of the man going from Washington to Baltimore and becoming sunburned along the way.

c. *Our Account and Modern Science*

Those of us who are accustomed to the terminology of modern science with its atoms, energies, and other such realities and those of us who even find it hard to think of science in the Aristotelian sense

may be quite unsettled at this point. What is the relation between primary matter and two contraries on the one hand and, on the other hand, the entities studied by atomic physics? Is primary matter a thing like neutrons or protons or some other fundamental particle, and are the contraries the number of fundamental particles as they vary from one kind of atom to another? Such questions are raised here only to remark that they are premature. For we are dealing with material reality at a level much too general and too vague to employ the very particular and very distinct concepts so usefid in modern physics. We are dealing with mobile being as we can know it at the beginning of our science, whereas the atomic theory, together with its refinements, can only be introduced after our general science of nature is behind us. At the proper time and place, it will be suggested that chemistry and atomic physics, together with biology when it is a case of living things, can enlighten us concerning the subject and two contraries that we have found in accidental change and concerning the first subject and the first contraries revealed in the order of substances. But for the present and at our highly general level of analysis no correlation should be attempted between the first principles of motion as revealed by our induction and the entities supposed by modern specialized research. Experiment and measurement, as providing us with refined and specialized dialectical inductions that there are atoms and parts of atoms, can at most fill out the details concerning the first contraries and their subject which are known to us prior to deliberate experimentation and measurement. The knowledge that there are substantial changes takes place at a much more general and hence more certain level of our science than any evidence tending to deny substantial change, and hence no arguments from modern mechanistic theory can deny the reality of substantial change. In its general notions of nature the mind, as we have seen, is most trustworthy and certain; any contrary evidence is uncertain and obscure.

V. SUMMARY

To summarize the progress of our chapter, it can be shown that all successful students of material things attest to the existence of opposites in any change. At the root of all motion is the first subject of the change, or primary matter, with the two first contraries that we have been so far calling possession and privation. Primary matter and its two contraries are revealed to us by substantial change, i.e., changes of the

whole mobile being like wood, iron, cats, etc., as opposed to accidental or partial changes like alterations in color or size. Primary matter and two first contraries are the first principles in any and every mobile being. It is not necessary to name these principles in any particular change like that of wood as opposed to that of iron, because that would involve a more particular kind of knowledge than what is available so far.

So much for our progress so far. It has involved a dialectical reasoning to the following two propositions: (1) substantial changes occur; and (2) substantial changes embody a primary subject and two first contraries. Both of these propositions, the conclusion of dialectic, can be empirically verified by induction.

REVIEW QUESTIONS

1. Compare the Aristotelian dialectic in search of first principles with the modern scientific method, taking scientific here in the sense of modern science.
2. Why is it possible for Aristotle to use a simpler and more certain procedure?
3. In what way does modern science argue to the existence of opposites in nature?
4. Define contrariety.
5. Show that motion involves contrariety.
6. Give evidence for substantial changes and contrast such changes with accidental modification.
7. Show that it does not involve specialized branches of our science of nature to make this distinction.
8. Prove that substantial change involves contraries and that these contraries are first principles.
9. Show that a subject is required in accidental change and also in substantial change.
10. What is the relation between accounts of matter in modern chemistry and physics and the notion that the first principles of nature are primary matter and two contraries?

PROBLEMS

I

Paraphrase the following passage in the light of discussions in this chapter:

> "Our first presupposition must be that in nature nothing acts on, or is acted on by, any other thing at random, nor may anything come from anything else, unless we mean that it does so in virtue of a concomitant attribute. For how could 'white' come from 'musical,' unless 'musical'

happened to be an attribute of the not-white or of black? No, 'white' comes from 'not-white' — and not from any 'not-white,' but from black or some intermediate color. Similarly, 'musical' comes to be from 'not-musical,' but not from any thing other than musical, but from 'unmusical' or any intermediate state there may be.

"Nor again do things pass into the first chance thing; 'white' does not pass into 'musical' (except, it may be, in virtue of a concomitant attribute), but into 'not-white' — and not into any chance thing which is not white, but into black or an intermediate color; 'musical' passes into 'not-musical' — and not into any chance thing other than musical, but into 'unmusical' or any intermediate state there may be.

"The same holds of other things also: even things which are not simple but complex follow the same principle, but the opposite state has not received a name, so we fail to notice the fact. What is in tune into untunedness — and not into any untunedness, but into the corresponding opposite. It does not matter whether we take attunement, order, or composition for our illustration; the principle is obviously the same in all, and in fact applies equally to the production of a house, a statue, or any other complex. A house comes from certain things in a certain state of separation instead of conjunction, a statue (or any other thing that has been shaped) from shapelessness — each of these objects being partly order and partly composition.

"If then this is true, everything that comes to be or passes away comes from, or passes into, its contrary or an intermediate state. But the intermediates are derived from the contraries — colors, for instance, from black and white. Everything, therefore, that comes to be by a natural process is either a contrary or a product of contraries."

Aristotle, *Physics*-6

II

Find in the following passages any evidence that the authors hold to contrariety in the world of mobile being:

"We have elsewhere explained that there was contained in material things something which has to be added to mere extension, and is really prior to it, viz., a natural force implanted by the Creator in all things. It does not consist in that mere 'potentiality' with which scholastic philosophy seems to be content, but is characterized by an effort (conatus) or nisus which, were it not limited by a contrary effort would also come to complete realization. This tendency is often apparent directly to the senses, and also, even if not apparent to sensation is, in my judgment, known everywhere in matter by means of reason. As it is not our concern now to refer this force miraculously to God himself, we must assume that it has been placed by him in bodies themselves, verily to constitute their innermost nature. Since activity is the characteristic mark of substances, extension on the contrary affirms nothing other than the continual reiteration or

propagation of an already presupposed effort and counter-effort, that is, resistant substance, and therefore, extension cannot possibly constitute substance itself."

Gottfried Leibniz, *Essay* on Dynamics[27]

III

"The nature of the problem has been clearly and briefly stated by Professor Henry Semat in his *Introduction to Atomic Physics.* He says: 'The results of the experiments on the Compton effect leave no doubt that, in its interaction with matter, radiant energy behaves as though it were composed of particles. A similar behaviour was observed in the photoelectric effect. It will be shown later that in the processes of emission and absorption light behaves as though it consists of corpuscles. But the phenomena of interference and diffraction can be explained only on the hypothesis that radiant energy is propagated as a wave motion. We are thus led to the conclusion that radiant energy exhibits a dual character, that of a wave and that of a corpuscle.' Semat also quotes L. de Broglie, who, he says, was led by considerations based upon the special theory of relativity and upon the quantum theory, to advance the hypothesis that 'the dual character, wave and particle, should not be confined to radiation alone, but should also be exhibited by all the fundamental entities of physics. On this hypothesis, electrons, protons, atoms and molecules should have some type of wave motion associated with them.' He adds that 'results of . . . experiments confirm de Broglie's hypothesis that there is a wave motion associated with every moving electron.' Schrodinger says: 'A vast amount of experimental evidence clinches the conviction that wave characteristics and particle characteristics are never encountered singly, but always in union; they form different aspects of the same phenomenon, and indeed of all physical phenomena.' Richtmeyer and Kennard say that 'Even molecules should exhibit wave properties under suitable conditions, according to the new theory. This, too, has been verified by experiment.'

"The conception of a single entity with a dual character, at once wave and particle, is hard to understand. It is not made the easier by the suggestion, usually advanced in this connection, that these are two 'aspects' of the same phenomenon. What is meant by the word aspects?"

Herbert L. Samuel, Essays in *Physics*[23]

NOTES TO CHAPTER IV

1. Bk. I, ch. 2, 184b, 15-22. Unless otherwise noted, direct citations from Aristotle's Physics are taken from the Oxford translation and are used with the permission of The Clarendon Press, Oxford.
2. It would be hard to find a better concise summary of dialectical procedure than J. Dewey's "Analysis of a complete act of thought" in How We *Think* (Boston, 1910), p. 68 ff., esp. p. 72.
3. Newton exemplifies what Frank and Dewey describe. Cf. L. Stebbing, A *Modern Introduction to Logic* (London, 1953), p. 313 ff.

4. Cf, Chapter III, n. 36.
5. Cf. ibid., n. 35.
6. Com. *on the Eth.,* Bk. VI, les. 7; *Book of Causes,* les. 1.
7. Bk. I, ch. 3-4.
8. Bk. I, les. 2-9.
9. Cf. supra, n. 2.
10. Phys., Bk. I, ch. 5, 188a, 18-19.
11. Com. on *the Phys.,* Bk. I, les. 5, 7; Com. on *the Met.,* Bk. X, les. 10, n. 2123. For secondary literature, cf. J. Anton, *Aristotle's Theory of Contrariety* (New York, 1957).
12. Phys., Bk. I, ch. 5, 188a, 33-35; Com. on *the Phys.,* Bk. I, les. 10, 4.
13. Sum. cont. Gent., Bk. II, Ch. 31; On Truth, q. 8, a. 3.
14. Phys., Bk. I, ch. 6, 189b, 23-25; Com. *on the Phys.,* Bk. I, les. 11, 4.
15. As is well known, Aristotle wrote a book called the Categories in which he studies what men mean by the ten supreme kinds of predicates he finds represented in their speech.
16. Com. on *the Phys.,* Bk. I, les. 11, 15.
17. It is true that the determination of the properties of primary matter belong later, even in metaphysics, but by induction, the science of nature can establish matter's existence (Com. on *the Phys.,* Bk. I, les. 12, 10).
18. Com. on *the Phys.,* Bk. I, les. 8, 2. See also Com. on the *Met.,* Bk. VIII, les. 6.
19. Cf. John of St. Thomas, Curs. Phil., Phil. Nat., I. P., O. II, art. 1, ed. Reiser (Turin, 1933), II, 43 ff.
20. For various meanings of the term privation, cf. Com. on the *Met.,* Bk. V, les. 20, nn. 1070-1073; Bk. IX, les. 1, n. 1785; On the Power of God, q. 9, a. 7, reply 11.
21. Com. on the *Met.,* Bk. X, les. 6, n. 2036 ff.
22. Phys., Bk. I, ch. 5, 188b, 30-33; Com. on the Phys., Bk. I, les. 10, 6.
23. Com. on the Phys., Bk. I, les. 11, 4 and 15.
24. *Phys.,* Bk. I, ch. 6, 189a, 34-189b, 15; Com. on the Phys., Bk. I, les. 11 (passim); On the Power *of God,* q. 3, a. 2.
25. Contraries are treated by Aristotle in the Categories, chs. 10-11.
26. Bk. I, ch. 5; 188a, 32-188b, 26.
27. Quoted in *Leibniz: Selections,* ed. P. Wiener (New York, 1951), pp. 119–120. Reprinted with permission of Charles Scribner's Sons.
28. New York, 1952, pp. 131-132. Reprinted with permission of Harcourt, Brace and Company, Inc.

CHAPTER V

PRIMARY MATTER AND ITS FORM

I. DIALECTIC THROUGH LANGUAGE AND ART

a. *Testimony From Language*

Opinion received from successful students of the physical world is at least one way of raising the dialectical questions which lead, at last, to the inductive knowledge that nature has three first principles: primary matter and two first contraries. The analysis of language and of art, the two other dialectical devices already mentioned,[1] likewise prepares the way for the same inductive conclusion and does so in an even more positive[2] fashion than the opinions of other thinkers. If first principles can be found in material things, a science of nature becomes possible.

Following Aristotle's own example,[3] let us analyze the various grammatical forms for describing the process of learning music. It is possible to characterize a person's learning of music in at least three ways: "The man becomes musical"; "Tire non-musical becomes musical"; and "The non-musical man becomes a musical man."

The third manner of speaking is more complete, and it will be instructive to see how this third statement reveals the principles of coming-to-be.

In spelling out that "The non-musical man becomes a musical man," a speaker tells us that there is a man, that he was non-musical at the beginning of the process, and that he is musical at the end. Our dialectical conclusion based on this use of language invites the mind to induce the following propositions about mobile being: there is always a subject

to which motion is attributed, e.g., man; there is something new which exists in the subject as the result of the motion, e.g., the quality of being musical; and this new item could be brought into existence through motion only if it did not exist within the subject undergoing motion beforehand, e.g., only if the subject were previously non-musical.

As shown by our induction, change involves something complex at both its beginning and its end. At the beginning, there is the composite of non-musical and man; and at the finish, there is a composite of musical and man. To say that "The non-musical man becomes a musical man" is a more complete and hence more perfect way of describing the process of learning music than either of the other two propositions we have cited above; what is described by these two other propositions would, upon analysis, be found to be more fully expressed by our third proposition. When we say that change in general involves the complex, we are actually using a different line of approach to establish the same conclusion which we reached in the previous chapter: in any change, there is a subject, e.g., man, and two contraries, e.g., non-musical and musical. When the change involved is substantial, the complex term at the beginning of the process consists of the first principles, primary matter and privation, while at the end of the process there are the first principles, primary matter and a possession.

Such are the dialectical conclusions based on our language. An inductive test will make them certain.

b. *Examples From Art*

Our dialectical search can also take a cue from the world of art. In the making of a statue, for instance, bronze that lacked a definite figure at the beginning of the sculpturing possesses that figure at the end. Here again there is a subject (bronze), a privation (the lack of the figure), and possession (the having of the figure).[4] In an awkward but succinct way of describing the process of sculpturing, unfigured bronze becomes figured bronze. Once more each end or term of the change is complex. In the building of a house, matter which is deprived of a certain shape at the beginning possesses it at the end.

A similar fourfold structure can be found in every type of coming-to-be: (1) a subject which (2) did not have a certain character is now, because of change, (3) the subject (4) having the character in question. The subject is the same at the beginning and at the end of the process. It is the same man who is first non-musical and later musiçal, the same

bronze that lacks a figure and then possesses it, the same material that formerly was not in the shape of a house and later had such a shape. It can be argued, then, that there are three principles of motion, a subject and two contraries; it can be further argued that there are three first principles of substantial change, primary matter (the subject that undergoes substantial change) and the two first contraries which such change embodies (possession and privation).[5] In every process of becoming, there is (1) that which terminates the change and (2) that to which the change is attributed. And the latter is twofold, namely the subject and the contrary of that which terminates the process. Hence it is evident that in any process of becoming three principles are involved: the subject, the terminus of the process, and its contrary. For example, when a non-musical man becomes a musical man, the contrary is the non-musical, the subject is the man, and the terminus is the musical.

II. NOMINAL DEFINITIONS

a. *Three Requirements for Motion*

In the reddening of an apple, an apple that was not red becomes red; in the growth of a dog, what was not large becomes large. From not being on the ground, a falling snowflake becomes present on the ground. Even in changes of substance, as in the burning of paper, the rusting of iron, and the assimilation of food by living things, there must be a subject which remains constant throughout the process and, by the end of the process, acquires a character that it could not claim before. Substantial change, as illustrated by the examples just given, is a change of a whole mobile being rather than an accidental or superficial modification; and here too there is a subject which has at the end of the change something it lacked at the beginning.

Accidental change requires a subject plus two contraries, and substantial change requires a primary subject with two first contraries. Primary matter and its two first contraries are the first principles of nature.[6]

b. *Subject, Form, and Privation*

By way of establishing now some nominal definitions, there is something in any change, whether accidental or substantial, that remains throughout that change. This stable something that persists through

change is the subject that we call matter.' In the case of substantial change, this subject is primary matter; and by contrast the subject in accidental change, the substance that receives new accidents, may be called secondary matter.

In addition to the subject which persists throughout the change, there is a new modification which the change brings about. The subject acquires a new attribute. This new modification or attribute is called form, accidental form in the case of accidental changes and substantial form in the case of substantial changes.3

As we know from freshman Latin, matter (materia) once had the meaning of forest, and since wood is a common subject for man's making of things, it is easy to see how the term matter could be widened to mean any subject of change. Form obviously originally had a geometrical meaning. Shape is the form that we know most exactly; but since shape is a terminus or boundary, the term form could be imposed to mean the terminus or end of any change.

A warning is in order here lest matter in the sense in which we are using the term be confused with matter9 in its ordinary meaning of that which has weight and occupies space, and there is an even stronger temptation to think of form as meaning only shape or figure.10 Substantial change, as we have seen, is a change of a whole mobile being, yet there is some perduring subject (primary matter) which remains throughout the change. Hence it is obvious that, when we speak of primary matter, we have in mind something much more fundamental than the derived characteristics of material reality, such as having weight and occupying space. Matter, in our nominal definition of the term, means the subject of change;11 primary matter is the subject of substantial change, and secondary matter or substance is the subject of accidental change. Form means no more (and in fact no less) than the modification or termination of matter; it is substantial form that terminates primary matter and accidental form that terminates secondary' matter or substance.

Matter and form provide us with two of our first principles for change. But, as we have already seen, every change requires a subject and two contraries. Matter is the enduring subject of change; form is the contrary modifying matter at the end of the process of change; and privation is the other contrary motion involves. As such it is our third principle for change. Privation is a principle in both substantial and accidental change. Accidental change requires the previous privation of the form that is to result from the motion; and substantial change

requires the antecedent lack or privation of that substantial form which is to be present at the end of the process.12

III. PRINCIPLES IN ACCIDENTAL CHANGE

Let us analyze some cases of accidental changes, which are the changes best known to us, in order to show that motion would be impossible if either a subject or either of two contraries, the form or privation, were taken away. By extending this analysis to substantial change, it will be possible to confirm the inductive knowledge that here also there is a subject and two contraries called substantial form and privation. If it can be argued that accidental change would be impossible without a subject and its contraries, it can surely be concluded that these three items are principles in nature; and by extending the same analysis to substantial change, it can finally be concluded that the first principles of nature are a primary subject together with its contraries in the genus of substance.

a. *Subject*

There must first of all be a subject in all motion. If an apple is to grow red, there must first of all be an apple; reddening does not go on apart from some subject like a fruit, a vegetable or, say, human skin. For the falling of snow, there must first of all be snow. In the example of the puppy growing up, there is a subject of the motion, the dog, which was little at the beginning of the motion and is large at the end. The growth of a dog is distinguished from the growth of a cat not because they both involve growth — for to this extent both cases are alike — but because there is a dog in the one case and a cat in the other. Tire fall of snow is different from the fall of a leaf not because they both involve falling — for to this extent they are alike — but because there is snow in one case and a leaf in the other. Likewise, the reddenings of a tomato and of an apple are alike to the extent that reddening is involved but different in involving respectively an apple and a tomato. If growing involved no subject, all cases of growing would be alike. Falling as such implies no difference in what falls. If reddening would take place apart from a subject, tomatoes and apples would be alike. Indeed, there would be no such fruits at all, only their color. Hence, a world of pure motion, *a* world where there were no subjects, would be an undifferentiated world where everything would be like everything

else, and none of the rich variety and striking order in our present cosmos would appear.[13]

b. *The Contraries: Form*

In addition to the subject in change, there is a new modification which the motion brings about. This is called form, substantial form if the change is substantial change and accidental form if the change is only accidental.

The apple, upon reddening, does not have the same characteristics as before. Something new is acquired, in this case a new color. Because of falling, a snowflake takes on a position different from the one it had before the fall; and in drifting with the wind after landing on the ground, the flake can take on still newer positions. As in the case of the apple, so in regard to the snowflake something new has been given by the motion to a stable and abiding subject. In growing to adult size, the dog receives a new modification or attribute; in our language, it receives a new form. It is still the same subject with the same pedigree, the same color and texture of hair, and perhaps the same kind of responses to the same master. But it has a new size, a new form. By motion, a subject is "modified" or "qualified" through the attainment of a new form.[14]

In many cases, it may be quite difficult and often impractical to determine with any precision what the subject in this or that motion is and what the form is. This sort of information, if and when obtained, would be fairly exact knowledge, and such details can be discussed and decided only at a later stage of our science than the one where we now are. To be ignorant of the more precise nature of the subject and the form in any change does not destroy the more general knowledge that motion always involves such principles. For if there were no subject in motion, there would be pure and undifferentiated motion; and if there were no form, if there were nothing new as a result of the motion, the mobile being would be the same as it was before and there would be no motion at all.[15] For these reasons, we can defend our induction that motion essentially requires a subject and a form.

c. *The Contraries: Privation*

However, there is one more principle involved in motion; the subject characterized at the end of the process by the newly received form

cannot have that form beforehand if the motion is to take place. If it were already in possession of the form, the subject could not acquire that form through motion, and hence motion toward the form could not occur. The flake of snow already on the ground cannot fall to the ground. There is no reddening for an apple that is already red, no growth to adulthood for a dog that is already an adult. If there were no initial lack of the form which a motion is to bring about, the subject would already possess at the beginning of the motion the modification that is to come at the end, and it is absurd to speak of motion to an end already attained. You fill a glass to the extent that it is empty and not to the extent that it is full. A thing that already owned what a motion would bring to it could not undergo the motion in question. That is why our third principle, the initial privation of the new form, is necessary to all movement.

Change, then, always requires a subject or matter, a form or possession on the part of the subject, and the privation opposed to this form. Mobile being requires a subject and two contraries as its principles.

IV. THE FACT OF SUBSTANTIAL CHANGE

a. Two Types of *Becoming*

In the genus of substance, or fundamental material being, change involves primary matter, substantial form, and the privation of that form prior to change. These are the three first principles of nature, a primary subject and two first contraries. They are not derived from anything else in nature, and from them everything else in nature is derived.

Experience reveals that there are two types of becoming in nature: one is the coming-to-be of a new substance; the other is a coming-to-be in the order of accidents. The burning of wood and the assimilation of food are examples of the first type of change; the transportation of wood and the reddening of an apple illustrate accidental modification. In substantial change, there is a simple or unqualified coming-to-be; a whole new material being comes about. In accidental change, a thing comes to be in a relative or qualified way, i.e., not according to its whole nature but according to some attribute inhering in that nature as an accident in a substance. “A substantial form differs from an accidental form in that an accidental form does not give existence in an unqualified sense, but a modified type of existence, as heat makes its subject not

to exist as such, but to exist as something hot. . . . But a substantial form gives existence in an unqualified sense; hence by its reception something is said to come to be absolutely."[16] Prior to the burning of wood, it could be said that the ashes did not exist; after the burning, they exist. Hence, simple and unqualified becoming is a transition from non-being to being, i.e., from the status of non-existence to the status of existence.[17] Relative or qualified becoming is a change not from not-being to being but from not being thus to being thus, e.g., from not being red to being red. Prior to the reddening of an apple or the local motion of the wood, it could be said that the apple and the wood existed but not according to this or that attribute, like being red on the part of the apple or, on the part of the wood, being here rather than there. In substantial or unqualified coming-to-be, the process brings a whole thing into existence. Prior to coming-to-be in a substantial way, water, wood, or apples do not exist. In superficial or qualified becoming, the process makes a thing, already in existence, to be thus and so, e.g., to be hot in the case of the water.

b. *Accidental Change*

It is not difficult for the mind to make the necessary induction leading it to conclude that in all instances of relative or accidental change a perduring subject (secondary matter) and two contraries are required. In fact even in order to think about motion at all, the human mind cannot help thinking of a constant something that undergoes motion and of a newly appearing possession, at the end of the motion, of something that was lacking before. No one could be aware of the movement of a finger unless, in some implicit and unanalyzed way, he were aware of a subject, the finger, the lack of a position that the finger will later have, and the later having of that position. Long before a college course animated by the *Physics* of Aristotle, the readers of this book were using a subject and two contraries in order to represent motion in their own minds. Without these three principles one cannot even think of motion. Hence, Aristotle did not invent the three requirements for motion and impose them upon willing listeners; on the contrary, he merely found out what we must conceive in our minds to think about motion. His insistence on a subject plus two contraries in our concept of motion merely makes explicit what has been implicit in our minds from the time those minds first noticed motion going on about us. Hence to think about motion anywhere and at any time is, in

paraphrase of Cardinal Newman, to think like Aristotle. Even the modern scientist, in order to conceive motion long before his technical work and in fact all during such work, must think of a subject, a form, and a privation. The awareness, at least implicit, of these three principles is thus presupposed by modern physics, chemistry, and biology; no one could think of our world without them. They are so easy and unnoticed in our knowledge that we are not even aware of them, and so the scientist in the modern sense of the term, unaware of what he is really presupposing, thinks he can erect a science without dependence on these principles. But they are not unused by him; they are just unanalyzed and uncritically accepted; they are so easy and natural that he does not know he is using them. That is why it has been emphasized that there is a general science of nature prior to the specialized studies which, by essentially the same dialectical method, continue the investigation of the physical world begun at a truly universal level.

c. *Substantial Change*

In substantial change, also, there is a subject, a form, and a privation. If any of these principles be absent, change cannot be conceived; these facts offer certain evidence for our induction that all substantia] change requires these principles.

It was argued in the previous chapter that it is appropriate for the general science of nature to distinguish between substantial and accidental change. Such a distinction is presupposed to further scientific knowledge of nature, for such a distinction provides us with our initial recognition of the distinction between the essential or fundamental and the accidental or superficial without which a deliberate, organized knowledge of nature at any level simply cannot come about. In all the motions possible in wood, like changes in place or alterations in color through the bleaching action of sunlight or burning or rotting, how far can you go and still have wood left? In testing a new drug on a lower animal or in subjecting an animal to radioactive fallout or supersonic speeds, how much can an animal stand without dying and thus ceasing to be an animal? Such questions show that the human mind, even in specialized research, makes a distinction between fundamental and superficial changes in nature. That these two changes are of a different order and type cannot be denied without undermining all organized knowledge of the essences of things in nature, since such knowledge is based upon the question of how far such things can be accidentally altered without

being substantially destroyed. Until we know that man himself is capable of dying and hence of undergoing substantial change like things in nature, we do not even know the meaning of our own lives.[18] Substantial change is thus fundamental not merely in nature but also in our knowledge of nature. To ignore the distinction between substantial and accidental change would be to make that small error in the beginning of a science which leads to a large error at the end.

V. MODERN SCIENCE AND OUR PRINCIPLES

a. *Denial of Substantial Change*

In the previous chapter, it was also claimed that the study of the general aspects of substantial change does not have to await the findings of chemistry and atomic physics. It is true that detailed knowledge of this or that substantial change requires exact, experimental observations; nevertheless, the basic distinction between accidental and substantial changes in nature is a pre-experimental and premathematical problem belonging to the general phase of our science and decided by common experience properly analyzed. The answer to this pre-experimental and premathematical problem is presupposed by chemistry and physics; for these studies must distinguish between what is essential to things and what is only accidental and thus require advance knowledge of such a distinction. The distinction between substantial and accidental change, together with a general discussion of the principles proper to each, thus truly belongs in the general science of nature.[19]

It would not be necessary to dwell on this point were it not for the fact that science in the modern sense of the term has tended to deny the fundamental distinction between what we have termed substantia] and accidental change. Accordingly, the remaining part of this section can be considered as a parenthesis to be read only by those who have special difficulty in reconciling the notions of primary matter and substantial form with theories from modern chemistry and physics concerning the structure of matter. If we were following the proper pedagogical order moving from knowledge that is vague and general to notions that are more precise and more particular, we would not be bothered by comparing our view of change with the atomic theory' simply because we would not yet know, so early in our science, about the fundamental particles in nature. It would be logical, although

extremely difficult, to forget for the moment about our previous knowledge of atoms and their parts and imagine ourselves to be starting out to construct a unified science of nature according to the proper order.

For several centuries, the opinion has been current that all of the motions in nature can be explained as change of place and hence as accidental change. According to atomic physics, hydrogen has a single proton as its nucleus and helium has two such protons (and ordinarily two neutrons). Accordingly, hydrogen can be made into helium by adding a proton to the nucleus; and helium in turn, on losing a proton, becomes hydrogen. The chemical difference between all the elements is the difference in the number of nuclear protons, and the conversion of one element into another is a case of adding or subtracting such protons from the nucleus of any element to be so changed. Interpreted only in this light, the conversion of helium into hydrogen or of hydrogen into helium would not be the substantial change that our general science would call it; rather, the interconversion of elements would be a case of local motion in which protons would go in or out of a nucleus almost as though eggs were put in or out of a basket. Such a view would regard substances as being aggregates of tiny particles, and so-called changes of substance would be nothing but changes of position by these particles, i.e., accidental change. This approach to nature is mechanism.[20]

But long before hearing about atoms and their parts, the mind, working at the level most certain and trustworthy, accepts substantial change almost spontaneously. When the wood is split, the mind recognizes that there is still wood. But when wood burns, we say, "It's all gone."

b. *Difficulty of Solving Our Problem Today*

The problem of defending our basic distinction between substantial and accidental change and of presenting primary matter and substantial form as necessary principles in grasping nature is complicated by sociological reasons. It is not the mind coming at nature naturally that will resist the teaching of primary matter and substantial form, but rather the mind that has chanced upon opinions in the wrong order and from the wrong places.[21] The induction to primary matter and substantial form will be difficult for those who think of science only in its modern sense, who think of atoms, neutrons, and many other technical entities as though they were as clearly known as billiard balls and as certain as the existence of fire when we see smoke.

Science in the modern sense has had such a good press today that

those who think of science in an older but much more critical sense almost appear as misfits. Not only can previous courses about the natural world make it difficult to think of change in the apparently strange and unexciting context of primary matter and substantial form, but our whole culture even at the popular level is attuned to science in its modern sense. The commercials of radio and of television join the newspaper headlines in discussing atoms, germicides, interplanetary travel, viruses, and other entities that indoctrinate the mind with modern science before it has a chance to explore that general level of material things which modern science presupposes. It is no wonder then that primary matter and substantial form, for reasons peculiar to our own age, are difficult to teach and to learn when, as a matter of fact, Aristotle could consider them in the very first book of his *Physics.*

c. *The Hypothesis of Atoms*

Whatever physics, chemistry, and biology have to teach us concerning substantial change, they are not in a position to affirm or deny that such a change exists in nature.[22] They cannot consider whether it is a change different in principle from accidental change. As an original and fundamental coming-to-be or passing away, substantial change is known at the level of general experience to be basically distinct from superficial changes like local motion or growth. The evidence for the existence of true substantial change, like the burning of wood as opposed to its mere local motion, is much stronger than any arguments to deny substantial change based upon the obscurely known and hypothetical world of atomic physics. Even more evident is the fact of substantial change in the death of a living thing whose substantial form is called a soul — vegetative, animal, or human as the case may be.

Atoms and their parts, in whatever is truly real about them, are not directly observable. They lurk beyond the range of even our most high-powered microscopes. They are known to us only because we can account for experimental results by positing them, better than we can on any other theory now known to us. It can be said with a very high degree of probability that they exist; it would be better to say that atoms and their parts have an extremely provable status in nature, and there is surely no ground to deny their reality even though there is no reason to affirm it as an absolute fact.

But even if atoms should prove to be real, our direct measurement of their structure will neither affirm nor deny whether they are each a

simple sum of smaller particles or a composite of primary matter and substantial form. For as shown in our previous example (pp. 27-28) of trying to distinguish a rational and an irrational animal, mere looks cannot decide the issue, and all the measurements we care to make concerning the structure of each creature will leave us equally in the dark concerning the fundamental difference which shows up when the two animals operate in their characteristic ways. Hence, it is not how an atom would look, when its structures are examined, which would decide whether it is substantially or only accidentally different from another kind of atom. Rather it is motions and operations of each kind of thing which reveal to us what each kind of thing is and how it differs from other kinds. If measurement cannot get at change as change, it surely cannot differentiate fundamental from superficial change.

When concepts like those in chemistry and atomic physics are first explained to us in precollege education and even more so when they are mentioned in popular media of communication, it is hardly ever sufficiently emphasized for us that atoms and their parts are hypothetical entities. They are, in fact, dialectical constructs or conceptual schemes that enable us to make inductions but not in the absolute and unqualified way which permits us to do away with the dialectical models themselves. They are thus known to us only through dialectical induction where there is always a margin of uncertainty. It is important to remember the status of atoms and their parts as being only hypothetically known when we compare our principles of primary matter and substantial form with explanations of substantial change based only on the atomic theory. It is much more evident that the burning of wood is a substantial change than it is apparent how atoms and their parts exist and behave.

d. *Adjusting Uncertain Knowledge to Certain Knowledge*

Let us agree that to make the induction to primary matter and substantial form as first principles we need dialectical devices like a reflection upon our language and an analysis of other works of art. The atomic theory too is another dialectical device used to make inductions that there are atoms and parts of atoms. If we had to choose between the two inductions, there is more evidence for primary matter and substantial form than there is evidence for any explanation in terms of atoms. Indeed our first evidence points to the fundamental distinction between substantial change and accidental change and to the existence

of a primary matter, substantial form, and privation, without which substantial change could not be represented in our intellect. If there is an apparent conflict between the notions of primary matter and substantial form and a popular-science explanation of change, it is the second kind of explanation which must be adjusted to the first and not the first which must be abandoned in favor of the second. Surely we ought to use what is better known, i.e., the familiar world, to explain what is lesser known, i.e., the dialectical constructs of atomic physics.[23] It would not be proper to use things so relatively obscure as atoms and their parts to deny what is relatively more clear such as the proposition that the burning of wood is a change of a quite different sort from its transportation.

In speaking of a conflict between the principles we are defending and the account of matter in a typical textbook of modern chemistry or physics, care must be exercised in our language and our logic alike. There can be no conflict or contradiction on the part of reality or on the part of the truth; whatever divergence there may be, if any at all, between the atomic theory and the principles of matter and form can exist only in our knowledge, or rather in our ignorance. How precisely the two accounts are reconciled involves specialized knowledge which is out of place in the general science of nature.[24] Our task in this chapter is to make the induction to primary matter, substantial form, and privation. Such an induction is based on general experience and is certain. Our later, more specialized, and less certain notions cannot replace previous certitudes on which these later notions themselves depend. On the contrary, their purpose is to provide details which can be fitted into our more general framework.

It is no counter-argument to say that reason, unaided by the scientific method of controlled experiment, can lead us into error, as in the case of the geocentric theory or in that of the stick, partially immersed in water, that looks bent. Both of these examples involve the mathematical properties of things, not strictly physical characteristics. Moreover, both of them involve detailed and particular considerations of matter, not basic and common characteristics which are most intelligible to us and involve the greatest certitude. For whatever is moving in the astronomical system and whatever be the status of the "bent" stick, they still involve a subject and a form, though we may err concerning what the subject and the form precisely are.

To end this phase of our inquiry on a positive key, substantial change or absolute coming-to-be goes on in nature, as general experience attests

and as no other experience can deny; and it is of a quite different fabric from accidental change or relative coming-to-be. Its principles are primary matter, substantial form, and privation — the three first principles of mobile being. Without these principles, we could not even think of substantial change just as motion could not be represented in our concepts without a subject and two contraries.

VI. PROOF FOR THE FIRST PRINCIPLES

John of St. Thomas,[25] one of the great commentators on the works of St. Thomas, offers two dialectical arguments to support the induction that in substantial coming-to-be there is a first subject of all change, called primary matter, together with the substantial form and its privative opposite.

a. *Substantial Form and Privation*

The first argument states that substantial changes do occur and concludes from this to the existence of the two contraries in the order of substance, substantial form, and its privation.[26] For if substantial changes occur, there is the substantially new — the substantial form — which was not present before and was thus in privation. And if substantial changes do occur, the form possessed at the terminus of the change must have been absent at its inception. The occurrence of substantial change, as witnessed by common experience, thus requires substantial form and its privation which are the more apparent of our three first principles.

b. *Primary Matter*

The second argument offered by John of St. Thomas is based upon the commonly accepted maxim that nothing can come from nothing. This proposition is supposed to lead us to the knowledge that there is primary matter in the change of substance. If nothing can come from nothing, then even though there is the substantially new as the preceding discussion showed, something must remain constant from the old substance; there must be a persistent substratum, an abiding matrix, an unchanging subject which receives the substantial form. This is what is called primary matter,

c. *Summary*

Our dialectical devices of analyzing language and describing the production of a statue have led to inductions reaffirming the conclusion of our previous chapter that motion always involves a subject and two contraries or, in another way of putting it, matter, form, and privation. At a level beyond more obvious but superficial change, there is substantial form and its matter. That such first principles of mobile being exist can be shown from two propositions: (a) substantial changes take place; and (b) nothing can come from nothing. Tire paraphrase of John of St. Thomas can be taken as a summary not only of the present chapter but of the most important argument so far developed in this book.

VII. PRIMARY MATTER, SUBSTANTIAL FORM, AND PRIVATION AS FIRST PRINCIPLES

a. Our First *Principles Are Physical*

In looking back over the road we have come in order the better to determine where we are, let us recall the requirements for our first principles: they must be physical, universal, and certain.

By contrast to the explanatory system in mathematical physics, our first principles are strictly physical. They are not principles of quantity. They do not merely depict the metrical structure of things or measure the forces and energies at work in accidental change like local motion. Primary matter and its two first contraries are strictly physical. They are involved in the coming-to-be and passing away of material being. They are more fundamental than quantity, structure, or anything else that we measure. They are at the root of all motion; they are the basis of anything that characterizes mobile being because they are the principles apt for bringing mobile being into existence. No resort to quantity and structure has been made in the establishment of our principles. They are through and through the principles of change because they are the minimum necessary to explain the fundamental change by which mobile or material being can and does come into existence.

b. Our First *Principles Are Universal*

In addition to being strictly physical in character, primary matter,

substantial form, and privation are universal; everything in the mobile world depends on them and is derived from them. Accidental being like color or sound depends on substantial being like wood or cats, and the substantial being itself depends on the primary matter and substantial form by which substance can and does come into existence. Everything in our sensible and mobile world is thus capable of coming into existence from primary matter, substantial form, and privation. From such principles, everything in this world is derived. Our physical principles are truly universal. Indeed, there is nothing more universal in the whole of nature; for if primary matter, substantial form, and privation came to be, they would, like all becoming, require matter, form, and privation. Thus, no motion or mobile being can occur without the first principles we have reached by our induction. As involved in all motion and as having nothing prior from which they come to be, primary matter, substantial form, and privation are truly universal. They are the sources of everything in this sensible world, and in this sensible world, there is nothing that is prior to them. What principles therefore could be more universal, i.e., more "first"?

C. *Our First Principles Are Certain*

Tire induction to primary matter, substantial form, and privation as first principles of mobile being requires the dialectical preliminary or conceptual scheme usual in any deliberate analysis of our physical world. But in the present case our dialectical devices based on received opinion, on language, and on the making of external works of art can be discarded when our induction has once been made. Our induction to facts based upon the atomic theory does not enable us to dispense with the atomic theory as our dialectical conceptual scheme. But the induction to nature's first principles is a matter of direct knowledge; it does not depend on dialectical constructs to be finally accepted by the human intellect. Our dialectical preliminary can be thrown away. It would be impossible to think about the change from wood to ashes unless the mind represented to itself a something undergoing the change, an old character that this something lost, and a new character that the something or matter acquired. Our principles are certain because without them the change in question could not even be thought about; far from denying or even ignoring such principles, any further explanations of fundamental change in nature must presuppose them, must begin with them, and hence must use them as true starting points or

first principles. Nothing is more evident or certain about substantial change than the existence of a primary subject and its form, and of the previous non-existence or privation of the form in question.

VIII. SUMMARY AN0 CONCLUSION

During the present chapter, the conclusion of the preceding chapter was induced in a more convincing way by a dialectic based upon linguistic and mechanical arts. From each source of reasoning, the mind is led to the induction that motion always involves a subject and two contraries and that substantial change involves a primary subject together with two first contraries. Primary matter and its two contraries are revealed to us when a whole being, e.g., wood, iron, or some animal, changes its character; this is a different kind of change from accidental modifications where a reality changes not according to its whole character but according to some attribute it possesses. Modern science cannot discount the difference between substantial and accidental change; such a difference is recognized as part of our general, pretechnical approach to nature, and it is presupposed to any further investigation. In the reconciliation which can be achieved between the Aristotelian and the modern account of so-called substantial change, we should begin with the position that is most certain and the easiest to establish and adjust the uncertain and more difficult knowledge accordingly. Primary matter and its two contraries are physical, universal, and certain principles.

REVIEW QUESTIONS

1. Show how language bears witness to the mind's recognition of a subject and two contraries in all motion.
2. Show by a dialectic based on art that a similar induction can be made.
3. Give a nominal definition of each of the three requirements for motion.
4. Show how each of the three requirements is different depending on whether the change is substantial or accidental.
5. Prove that there is a subject, a form, and privation in accidental change.
6. Differentiate between accidental and substantial becoming.
7. Explain why a discussion of the reality and nature of substantial change would precede investigations like those in modern science.
8. What objection can be developed out of modern atomic science to the account we have given concerning substantial change?
9. What is the sociological reason which makes it difficult today to solve this problem?
10. How would you face the objection that atomic theory denies substantial change?

11. What is meant by saying that uncertain knowledge ought to be adjusted to certain knowledge rather than vice versa?
12. How does this principle affect our present problem?
13. Give and explain the two propositions put forward by John of St. Thomas to prove the existence of primary matter and substantial form.
14. Show that our first principles are physical, universal, and certain.

PROBLEMS

In the light of the present chapter, comment on each of the following passages:

I

"Now that there is indeed an entity [primary matter] of such a potential and unformed character Aristotle deduced from two principles: First, from substantial generation itself, secondly from the fact that naturally nothing comes from nothing. And this second point is deduced from the first because if from nothing something would come to be, so that the whole substance of a thing would come from nothing, by this very fact there would not be generation but creation, and corruption would be annihilation. Hence, determinate dispositions would not be required for determinate generations, but it would be possible for a stone or a horse or any other thing to come to be in the same way, because if it comes from nothing there is no point to the dispositions which make it determined more to one thing rather than another. However, if it comes to be from something and what comes to be is a substance, from the fact that the generation is substantial it necessarily presupposes some subject capable of a new substantial existence and losing the existence which it had before because it is corrupted. Neither of these therefore it has of itself and consequently it is in potency to both of them."

John of St. Thomas, *Natural Philosophy*[27]

II

"This being true, it is necessary that mutation can be nothing else but motion of the parts of that body which is changed. For first, we do not say anything is changed, but that which appears to our senses otherwise than it appeared formerly. Secondly, both those appearances are effects produced in the sentient; and, therefore, if they be different, it is necessary, by the preceding article, that either some part of the agent which was formerly at rest, is now moved, and so the mutation consists in this motion; or some part, which was formerly moved, is now otherwise moved, and so also the mutation consists in this new motion; or which, being formerly moved, is now at rest, which, as I have shown above, cannot come to pass without motion; and so again, mutation is motion; or lastly, it happens in some of these manners to the patient, or some of its parts; so that muta-

tion, howsoever it be made, will consist in the motion of the parts, either of the body which is perceived, or of the sentient body, or of both. Mutation therefore is motion, namely, of the parts either of the agent or of the patient; which was to be demonstrated. And to this it is consequent, that rest cannot be the cause of anything, nor can any action proceed from it; seeing neither motion nor mutation can be caused by it."

Thomas Hobbes, Elements of Philosophy[28]

NOTES TO CHAPTER V

1. Cf. supra, p. 60 f.
2. Com. on *the Phys.,* Bk. I, les. 12, 1.
3. Phys., Bk. I, ch. 7; 189b, 33 ff.
4. *Prin. of Nat.,* n. 8; *Com.* on Phys., Bk. XII, les. 8.
5. Com. on *Phys.,* Bk. I, les. 12, 12.
6. *Prin.* of *Nat.,* 6.
7. Com. on Phys., Bk. IV, les. 5, n. 891.
8. Prin. of Nat., 6.
9. Cf. Newton's definition of mass as a "quantity of matter" in *The Mathematical Principles* of Natural Philosophy, p. 1.
10. For the meaning of "form" as structural pattern, cf. L. Whyte, *Accent* on Form (New York, 1954), p. 28.
11. Com. on *the Phys.,* Bk. II, les. 2, 2.
12. *Ibid., Bk.* I, les. 13, 3-4.
13. *Com.* on the *Met.,* Bk. I, les. 10, n. 152; Bk. IV, les. 12, n. 684.
14. Com. on *the Phys.,* Bk. I, les. 15, 10.
15. John of St. Thomas, Curs. *Phil., Phil. Nat.,* I, P., Q. III, a. 1, ed. Reiser (Turin, 1930), II, 56.
16. Summa *Theol.,* I, q. 76, a. 4; Prin. of Nat., 1-7.
17. Prin. of Nat., 8; Sum. *cont.* Gent., Bk. I, ch. 26.
18. This is the meaning of the Socratic definition of philosophy as a meditation on death. The existentialists have the great merit of raising death as a problem in an age which would tend to make it, like all other transmutations, a merely accidental and merely trivial change.
19. *Phys.,* Bk. 1, ch. 9, 192a, 33-192b, 3; Com. on *the Phys.,* Bk. 1, les. 12, 1.
20. The classical modern statement of the mechanistic view of change remains that of Descartes. "But motion is nothing more than the action by which any body passes from one place to another." Principles of Philosophy, Pt. II, Prin. XXIV. *The Phil. Works of Descartes,* transi. E. Haldane and G. Ross (New York, 1951), I, 265.
21. Cf. C. De Koninck "Introduction à l'étude de l'âme," *Laval* Théologique et Philosophique, III (1947), 12.
22. For a rather thorough misunderstanding of matter and form, cf. J. Needham, *History Is on Our Side* (New York, 1947), ch. II: "The Liquidation of Form and Matter."
23. ". . . there are philosophical facts that are much more simple, much more general, much more certain than the facts which are called scientific, i.e., the facts handled, linked, and interpreted by the natural sciences." J. Maritain, Philosophy of *Nature* (New York, 1951), p. 142.
24. But some discussion of it will have to occupy us later. Cf. Chapter VIII.
25. Curs. *Phil., Phil. Nat., I. P„ Q.* Ill, a. 1, ed. Reiser (Turin, 1930), II, 56.
26. Com. on *the Met.,* Bk. XII, les. 2, nn. 2429-2430.
27. Curs. Phil., Phil. Nat., I. P„ *Q.* Ill, a. 1, ed. Reiser (Turin, 1930), II, 56.
28. The English Works of Thomas *Hobbes,* ed. W. Molesworth (London, 1939), I, 126.

CHAPTER VI

PRIMARY MATTER: THE ROOT OF MOTION

I. MATTER AND PRIVATION

a. *Form and Privation as Contraries*

Form and privation are the contraries which all change involves, but contrariety has to be taken in a wide sense of the word in order to be extended to substantial form and privation and not restricted to accidents only. Strictly speaking, there is contrariety only where there is positive opposition like red and blue in the genus of the qualified or large and small in the genus of the quantified. Strictly speaking, then, only accidents have contraries. Between being and non-being, the two terms of substantial change, there is no contrariety except in a wide sense.[1] It would be better to refer to such opposition in the substantial order as privative opposition. It would be correct to say that change always involves a subject, a form, and a privation; it is not quite precise to say that change always involves a subject and two contraries. However, in our discussion, contrariety is being taken in a wide sense as applicable even to substance, and we can indicate the special character of contrariety in the order of substance by referring to it as a first contrariety.

But matter, either primary or secondary, is not one of the contraries. It is the subject in which the contraries succeed each other.[2] From one angle, then, form and privation, insofar as they are the two contraries, are more intimately related in change than are matter and form.

b. *Matter and Form as Essential*

However, form and matter in both accidental and substantial change are essential (per se) principles *of* nature, whereas privation is an incidental (per accidens) principle.[3] Tire difference between an essential and an incidental principle must now be explained.

A builder of a house could be a great many other things besides being a builder. He could be a musician, a member of this or that race, married or single, Catholic, Protestant, or Jew, and so on. Tire fact that a builder is also a musician is not essentially connected either with his art of building houses or with any of the acts within that art. To be musical is accidental to being a builder; and, by the same token, being a builder is accidental to being a musician. Building and music are not essentially connected.[4] In a similar manner, a leaf undergoing local motion in the fall wind may at the same time be turning brown; but the two motions, each of which has its own essential character, one in the genus of where and the other in the genus of the qualified, are related to each other in only an incidental manner.

Now matter and form, whether in absolute or relative coming-to-be, enter into the very constitution of the mobile being resulting from their union:[5] a red apple is essentially constituted of the apple as secondary matter on the one hand and of the accidental form of red on the other; the adult dog is a composite of the two essential principles of being a dog and of being an adult; in the generation of water, primary matter and substantial form unite to constitute the essence of water. As a consequence and sign of what has just been said, anyone wishing to characterize the mobile beings in our examples would have to define both the matter and form, e.g., red and apple, adult and dog. Matter and form, as principles, make an intrinsic and essential contribution to the resultant mobile being.

c. *Privation as Incidental*

But privation is not an essential principle. It is incidental to the coming-to-be of any mobile being, substantial or otherwise, as being musical is accidental to being a builder. The non-red of the apple does not enter into the coming-to-be of the red apple,[6] any more than music enters into carpentry or brick-laying. Indeed, to the extent that the apple reddens, the non-red ceases; there is a repugnance between

the privation, e.g., the non-red, and its contrary, e.g., the red. Unlike matter and form, privation does not enter into the composition of the thing made. A privation, for instance the non-red, is denied of the subject to the extent that the form, for instance, the red, comes into existence.

Matter and form are thus essential principles of coming-to-be, but privation is a principle in only an extrinsic and incidental manner. Hence it could be argued from one angle that there are two principles of motion —a subject (matter) and a form. But if we include the incidental and extrinsic principle of coming-to-be, there are three principles of change.[7] For bronze to be fashioned into a statue, it is not enough that it be bronze. It must also be deprived of the figure that is to be conferred upon it by the change.

d. *Privation and Matter*

Privation is not the aptitude for form.[8] Even less can it be considered as an incipient form of any kind. As the contrary and even privative opposite to the terminal form, it is repugnant to the form.[9] That is precisely why a subject is required in all motion. Privation and form cannot exist together but only successively. Hence a perduring subject is necessary as the common bond between the old and the new or as the matrix within which the privation and form succeed each other.

Privation has no existence separated from the matter in which it is found. In order to justify this conclusion, let us look again at our old friend, the man learning music. If we subject the proposition, "The non-musical man becomes a musical man," to examination, the following points will be obvious: The subject undergoing the change is one reality, namely, a man. All the reality that the privation non-musical possesses is dependent on the man. Before learning music, he is a man and he is non-musical. Non-musical and man are the same in reality, but not the same in our understanding of that reality.[10] Non-musical says something about the subject that man alone does not say. Privation is thus neither a form nor subject in motion but a kind of condition on the part of the subject without which the subject itself cannot acquire the form in question. Privation says something about the subject of motion which subject alone does not say. It does not add any new reality to the subject but adds only to our knowledge of the subject.

II. MATTER AND FORM AS POTENCY AND ACT

a. *Examples of Potency and Act*

In comparing the two essential principles of change, whether the change be substantial or accidental, it should be emphasized that matter means the same thing as potential being[11] and form signifies act.[12] The matter in an acorn is a potency for having the form of the oak; and when the oak tree comes into existence, the form of the oak actualizes the potency. The primary matter having the form of wood is in potency to having the form of ash; and this latter form would actualize this potency. Matter as such is thus always the passive or potential or determinable principle and form is the actual or determining principle. Primary matter is the ultimate substratum or matrix from which things are made;[13] and it is determined into this or that kind of mobile being by the act conferred upon it through substantial form.

Potency, from the Latin posse (to be able), has the meaning of possibility; and act, from the Latin agere (to act), has as its first meaning to operate. Act, however, is extended to mean any fulfillment or realization in being as well as in action.

Potency says capacity or aptitude, and act says fulfillment or realization. A man, about to cross a street, has the capacity to be on the other side and hence is in potency to being there. After the crossing, he will be on the other side in act, i.e., he will be actually there. With reference to our previous discussions, matter is the same thing as the potential, and form is the actualizing principle of matter. Matter is passive. It is indeterminate but determinable; form is the determining principle in all change. The man, about to cross the street, is indeterminate but determinable with respect to being some place on the other side; the future position, as accidental form, will determine this previous indeterminancy or potency and make the subject to be here rather than there. By means of form, an apple in potency to be red is actually so, and by means of form, this time in the substantial order, the matter potentially water is actually given the character of water.

b. *Primary Matter as Pure Potency*

Our contrast between act and potency has been necessary in order to lead up to the important proposition that primary matter is not only

potential but is pure potency.[14] Secondary matter is always in some way in act, although, as matter, it is in potency to a further and in this case accidental form. Secondary matter has a substantial form which determines primary matter so that this or that substance is made. An apple that receives a new color is in potency to the color, but it is not without an act of its own. It is actually an apple. Our little dog that is growing up is not purely potential since it is already a dog. In contrast to secondary matter, primary matter is purely passive. Apart from its union with substantial form, it has no act of its own. The only act that it has is the act conferred on it by form. It is a pure or primary subject; of itself it has no actual attributes. St. Thomas thought of it as a kind of chaos, organized by form.

We can prove that primary matter is pure potency by examining the unity observable in the operations of any substance. If, apart from substantial form, primary matter owned any act, then the union of substantial form and primary matter would be the union of two actual principles.[15] Two principles already actual could possess only an accidental unity like that of eggs juxtaposed in a basket; substance, composed of two actualities, would have the unity of only an aggregate or collection. This is not the kind of unity we observe in things. Act always gives independent and separate existence to things, and the union of two acts would be the unity of two independent units.

If primary matter had an act of its own, then any supervening form would not make the being to be simply existing, but would make it to be existing in this or that way, which is the function of accidental forms. Thus, if matter had its own act, then all forms would be accidents. If this were so, then the change involved when a living thing dies would not be a substantial change, but an accidental one. This is manifestly absurd. Consequently, the supposition that matter has an act of its own must be denied.

Experience reveals that substances have a unity that is more perfect than any accidental and extrinsic unity possible; their oneness can only be characterized by calling it an essential and intrinsic unity. Cats and dogs and rosebushes and inorganic substances like water or wood are not each merely collections or sums. Their being enjoys an inner and essential unity as shown by the fact that they each operate as a unit. The evidence is thus against the view that primary matter enjoys an act of its own and unites with substantial form to yield only an accidental unity. The only alternative is to maintain that primary matter is pure potency. The first act that primary matter receives comes to it from

its substantial form. It would even be a definition of substantial form to call it the first act of primary matter.

c. *The Meaning of Our Present Question*

In a very real sense, our present question is tied up with our problem in the past chapter where the account of change through primary matter and substantial form was compared to explanations of change based on the atomic theory. Our argument pointed out the fact that substantial changes do occur in nature and are quite different from accidental changes. Undeniable experience reveals to us that, after some of their changes, material beings have characteristics so different from those they possessed prior to being changed that the changes involved must have been substantial changes. Hydrogen and oxygen, mechanically collected into a vessel, would cause combustion when ignited; the same proportions of the two elements combined as water would extinguish the fire. Taken separately, sodium and chlorine would be harmful; as table salt, they form part of the normal diet of most of us. In their chemical compound of carbon monoxide, carbon and oxygen can be fatal to animals; separately, they are healthful and even necessary to various organisms. All of this indicates that the unity in a true substance is quite different from the unity in a mixture; one is substantial or essential unity while the other is extrinsic and accidental. The union of hydrogen and oxygen in a merely mechanical juxtaposition is accidental; the uniting of hydrogen and oxygen to form water is an intrinsic and fundamental kind of unity. In salt, sodium and chlorine are substantially united; and so are the carbon and the oxygen in carbon monoxide. The contrast between a substantial unity and a merely accidental one is a fundamental fact of experience.

Examples like those brought forward above led us in the previous chapter to the induction that substantial change takes place in nature. To admit substantial change is to hold, almost in the same breath, that primary matter is purely potential; for substantial change is impossible unless it be granted that the old and new things involved are two distinct units, each having an intrinsic character of its own as opposed to the extrinsic unity of an aggregate. If there are two distinct units, one at the beginning of the change and the other at its end, then each of these units must have, as one of its intrinsic principles, a purely potential element. It is this purely potential element (which we call primary matter) which perdures throughout the change. Were its

reality denied, the only alternative would be to deny substantial change and maintain that the processes we call substantial changes (the change of a blade of wheat into human flesh, for example) are in reality instances of annihilation and creation or else that the wheat is never destroyed but merely changes its place from the field to human flesh. In reality, then, the admission that primary matter is pure potency is implicitly contained in the affirmation of substantial change.

III. DEFINITIONS OF PRIMARY MATTER

a. Two *Nominal Definitions*

Our discussion during the present chapter has put us into a position to improve our definition of primary matter, but because only what is perfectly within the categories can be properly defined, our definition, even if bettered in the following paragraphs, will remain only nominal in character. We are trying to find out what we mean when we think of change and, in particular, what is implied by our concept of substantial or fundamental change. We are trying to find out what we mean when we say, as we do, that a whole substance changes and what is implied by our concept of the principles in substantial change.

Primary matter "is the first subject from which a thing comes to be essentially and not accidentally and which remains in the thing made."[16]

To define primary matter as a subject from which sets primary matter in contrast to all form, substantial or accidental. Form is always the act or end of the matter which it affects. It is not so much that from which a thing becomes what it is as it is that by which a thing is what it is. The human soul, for instance, is that by which man is man. To call matter a subject sets it off from form.

Primary matter is a first subject, and in this respect it differs from secondary matter or substance. A composite of our first subject and a substantial form, secondary matter is not a first subject but a derived one. It is not a pure subject but a subject to which a certain act has been attributed by virtue of the substantial form that it possesses.

Primary matter is a subject from which a thing comes to be. Consequently, it is something essentially related to change. As such, it is a physical or natural subject. It is not a subject in the context of a grammatical sentence or a logical proposition. It is not even the subject in a mathematical or metaphysical perspective. It is the subject from which mobile being can naturally come into existence.

In claiming that primary matter is that from which a thing comes to be essentially and not accidentally and that primary matter remains in the thing made, St. Thomas is contrasting primary matter with privation. Privation is only an incidental principle of coming-to-be and does not enter into the constitution of the thing made. Hence, our definition of primary matter by the roundabout language so characteristic of many nominal definitions enables us to understand what we mean by the substratum in any substantial change.

In another context, St. Thomas, following the lead of Aristotle,[17] defines primary matter to be "that which in itself, that is according to its own essence, is neither a 'what,' meaning neither a substance, nor a 'quality,' nor anything of the other genera by which being is divided or determined." The gist of this nominal definition, strong in telling us what primary matter is not, is that primary matter is purely potential.

b. Confusion of *Matter and Privation*

Our second definition here is a classic quotation but actually less helpful than our first definition. In returning to that first definition, it will be noted that the longest part of it is concerned to distinguish primary matter from privation. There are two points of difference mentioned. Primary matter in the first place is essential and not, like privation, accidental as a principle; and in the second place, primary matter remains within the thing made. Either one of these differences would have been enough; that the two of them are employed may have been a device to counteract by double emphasis a tendency on the part of the mind to confuse matter and privation and think of the beginning point of change as privation alone. Aristotle himself claimed to have been the first Greek philosopher to distinguish matter and privation;[18] probably the difficulties in purveying today the explanation we have given of substantial change stem more from a misunderstanding of matter than from anything else. Primary matter is the most difficult of the three principles in substantial change to conceive.

Privation is that from which a thing comes to be in an incidental way, and it does not abide in the thing made. For the little dog becomes a big dog not insofar as it is little, but insofar as it is a dog, Precisely as little, there is a cancellation of growth, a resistance or repugnance to being big. In an example used by St. Thomas, a bad man becomes good not because he is bad but because he is a man.[19] As bad a thing has a repugnance to being good. In a similar way, it is not wine that

becomes vinegar but the matter of the wine. The subject has a compatibility with the form; but privation is incompatible with that same form.

IV. THE APPETITE OF MATTER

a. *Why Motion Requires Appetite*

Form and matter are not merely compatible. To say that they go together in the formation of mobile being is to say something very true, but it is not to say it strongly enough. Form is the end or goal of matter.[20] The matter in any change is, given its dispositions in the change, ordered to form as to its purpose or aim.[21] The dog is ordered to be an adult dog, the apple to be a red apple, the matter in water or in ashes to have the forms of these substances, under given causal circumstances.

Matter, as matter, has a capacity or aptitude for form, and this capacity is its whole reality. The dog, in our example above, to the extent that it is matter is the capacity for being big, and the man, as matter in the operation we have named, is an aptitude or potency for being good. For what is in potency is always relative to act; act is the reason why potency exists.[22]

From the ordered character of natural change, a dialectician can argue that matter is ordered to form and hence that form is the end of matter. This fact of order in our cosmos has been pointed up before, and it has to be explained. Now order, as such, requires purpose or goal; anything that is not intended and hence not goal-directed would have to be written off as coincidence. The order in natural change cannot be passed off as coincidental. Order is always planned or goal-directed. If there is ordered change in nature, it must be purposeful or goal-directed.

b. *Matter as Having an Appetite*

What is the subject of this order, this "appetite" or "desire" for the results we observe in nature's changes? Privation, as such, does not have an appetite or order to anything else; of itself it is non-being, and non-being cannot have an appetite or order. In terms of a now familiar example, e.g., the green, the old form, in the apple does not have an appetite for the new form, e.g., the red; there is no seeking of one of these by the other because there is a repugnance between them as contraries. Far from seeking each other, they expel each other.

Nor can the appetite or order in nature be found in form. For form comes into existence only to the extent that a change is complete. Thus it is not present at the beginning of a change; hence it cannot be the subject of an appetite or order for the results of that change. If ordered change requires that there be an appetite or order in the principles of change, and if this order cannot exist in either of the two contraries, then the matter alone remains as the subject of order. Matter has an appetite for form. Form is, therefore, the goal or end of matter.

c. *Matter as Restless*

Matter can have only one form at a time.[23] A man cannot be married and single at one and the same time. As informed by the soul of a dog, primary matter cannot have the form of water; and if it has the form of water, it cannot possess the form of a dog. Hence, primary matter is never without privation; as actualized by one form, it is deprived of all other forms that its own character as pure potency would permit it to have.

As the most imperfect being, primary matter is the most restless of all realities. It is ever seeking to throw off one form and to acquire another. Its possession of any form is always precarious because such a form is always capable of being lost. The impatient and imperfect character of primary matter is the ultimate reason for change in our world. Even if we had no other arguments to prove the existence of primary matter, its reality would be suggested by the radical restlessness in the mobile beings of our experience. In accounting for any of the changes in our world, we are really telling the story of the restless search for perfection on the part of the first and pure subject of change. The history of our cosmos, from its remote past to its moving present, is the history of primary matter undergoing development. Without primar}' matter, this would be an immobile world, of interest only to a mathematician. It is primary matter that makes our universe to be physical, natural, and mobile.

V. MATTER AND THE PROBLEM OF PARMENIDES

a. *The Argument Against Change*

In their long struggle to understand the nature of motion, the Greeks encountered an unusual problem that is still instructive to us as a means

of grasping the character of matter. Parmenides, one of the first metaphysicians, had written off motion as impossible[24] and claimed that all knowledge of motion's reality is an illusion of the senses. If anything comes to be, he said, it would have to come to be from either being or non-being. From being, however, nothing can become. Whatever is being already is and does not come to be. On the other hand, nothing can come to be from non-being. In the language of the proverb, ex nihilo nihil fit, nothing comes to be from nothing. Since nothing can come to be from either being or non-being, motion, according to Parmenides, cannot occur[25] and is only an illusion of our senses, like a mirage.

b. *Solution of the Argument*

However, with the proper understanding of matter and privation as Aristotle presented it for the first time in the history of thought,[26] motion can be accounted for. Matter, as Aristotle pointed out, is truly being, although it is potential and not actual in character. The distinction between the actual and the potential enables us to escape from one of the two arguments of Parmenides. From being which is actual, nothing can become; however, from potential being or matter, things can come to be.[27]

Just as one of the arguments of Parmenides is resolved by the distinction between actual and potential being, so the other can be answered by distinguishing the essential and the accidental or incidental. Aristotle and St. Thomas agree with Parmenides in saying that nothing can be said without qualification to come from what is not. Nevertheless, they hold that a thing may come to be from nothing in qualified sense, since privation or non-being does not enter intrinsically and essentially in the change and since its total reality depends only on the subject which it affects prior to the change.[28] Nothing is made of non-being as part of its essential constitution; but something comes from non-being as from a pre-existing condition that does not truly enter the thing made. Privation, then, or relative non-being is an incidental principle of material being, whereas matter and form are essential principles inasmuch as they enter into the constitution of the reality brought into existence by the change.

VI. PRIMARY MATTER AS AN OBJECT OF KNOWLEDGE

a. Principles by Which

Primary matter is not, properly speaking, a thing; and neither is its form. Both matter and form are principles of things rather than things themselves. Neither one is a something which exists (principium quod), but rather each is principle by which a something, which is their composite, actually exists. As will be explained later, matter and form do not change but are the principles by which change comes about. The only realities that we can experience or experiment with, and indeed the only realities that we could observe if we looked down even to the dimensions of the atoms, are things which exist, such as sticks and stones and billiard balls. We do not observe the principles by which each mobile being is what it is but observe rather the mobile being itself which results from the principles. Hence no direct experimental observation can ever reveal substantial form and least of all primary matter; it can only advise us of the result of their union. They do not exist side by side like layers on a cake, but "permeate" or "compenétrate" each other.

b. Form: Matter:: Sight: Eye

In this context, two examples used by Aristotle may prove instructive during our temptation to seek pictures of primary matter and its form. If the eye of an animal were an animal, Aristotle proposed, sight would be its form or soul.[29] The form of anything is like sight with respect to the eye; and as sight is a principle organizing the eye so that it can see, so the substantial form of anything organizes primary matter into the structures and functions we observe.

It is no more mysterious to say that there is form in matter than it is startling to say that there is sight in matter. But the fact remains that one cannot see sight; it is not an observable phenomenon like the eye or a piece of coal or anything else that our senses apprehend.

Form, like sight which makes it possible for us to see, is one of the coprinciples of things we experience but is not itself the object of direct observation or experience. Only the results which form produces in primary matter are observable. Matter is the ultimate matrix within which the form achieves the structure we observe and measure in direct experience and in our laboratories. It is even better to regard it as a matrix from which form organizes our world.[30]

An experimenter can examine the eye; but a mere catalogue of ex-

perimental observations will never reveal what sight is. Once we know what sight is, the anatomical structure of the eye can tell us more about sight than we knew before; but knowledge of structure alone can never convey the notion of sight to one who does not already know what it is. The same relation holds in any context of primary matter and substantial form. That these principles are real can neither be confirmed nor denied by direct measurement or experimental observation; they are known by the fact of substantial change; but once we know of primary matter and substantial form, we can increase our knowledge of form by observing its effects in matter. This is where science in the modern sense, with all of its measurements and other structural knowledge, continues the general science of nature.

c. *Form Is Like a Habit*

Another example used by Aristotle to illustrate the meaning of form involves the three ways in which knowledge of a subject, e.g., geometry, can exist in the human intellect.[31] Prior to the study of geometry, the mind is potential to such knowledge; so one way of being related to geometry is to know it only potentially. Geometry may also exist in the human intellect as a habit. Equipped with the habitual knowledge of geometry, the mind may not be here and now performing geometrical acts; the person in question may even be asleep. But when such a mind does perform geometrical acts, it does not have to go back and learn the whole science from the beginning as it once did. Tire habitual knowledge of a subject enables a mind to perform easily and economically the acts that result from the habit. A third way in which geometry exists is in terms of individual actions flowing from the habit; this is the case with the man not only having habitual knowledge of geometry but here and now actually working problems in the science. The geometrical action is the result of the geometrical habit.

According to Aristotle, form is like the habit of geometry. Just as the habit gives a distinctive character to actions of which it is the principle, so form gives a determinate character to primary matter. But like sight and like any substantial form, a habit cannot be directly observed. We know it only by its results. Sight makes matter see; a habit makes its subject perform certain actions; more generally, form enables matter to be as experience reveals it.

d. Science: *Ancient and Modern*

Not capable of being directly experienced or experimented, primary

matter and substantial form are likewise the principles of the results we experience and experiment with. Carbon and copper each have a form analogous to sight with respect to the eye, which is a structural effect of sight in matter; each has a form analogous to the habit of geometry with respect to acts, which are the effects of that habit in the human mind. Experience and experiment reveal the function and structure of carbon and copper which in each case is the result of the form in queston actualizing or organizing primary matter. We see then not primary matter but effects produced within it by substantial form. If it were not so awkward in English it would be proper to describe gold as golden prime matter, an oak as oaken prime matter, and man as human prime matter. In our burning of wood, wooden prime matter is present at the start of the change and ashen prime matter at the end. Our chemical and physical discussion of the structure of each kind of thing enables us to know more about the effects produced by substantial form in primary matter, and in this fashion we get more knowledge of the form in question than would otherwise be possible. To this problem of the concrete relations between science in the Aristotelian sense and science in the modern sense we shall have to return.[32] Our present interest is only to discourage any tendency to think of primary matter and substantial form as things rather than principles by which mobile things come to be and pass away.

VII. SUMMARY

In this, our third and concluding chapter concerning nature's first principles, attention was focused on the fundamental reason which makes our world material and mobile, namely primary matter. Matter has been related to form as one of the essential principles of motion and to privation as an accidental principle of change. It was seen that matter is potency and primary matter pure potency; form is always the determining or actualizing principle of mobile being. In this chapter, our nominal definition of primary matter was improved; and it was argued that matter always has an appetite. Our fina] problems showed that a correct understanding of matter could solve the ancient dilemma of Parmenides and even throw light on the relation of science in the ancient sense to science in the modern sense of the term. Any use of science in the modern sense to prove the existence of primary matter, substantial form, and privation could be no more than a dialectical confirmation of what is really proved by other means. For the ultimate assurance of our three first principles is the inductive knowledge that substantial changes truly occur in nature

and, since nothing can come from nothing, there must be a primary subject persisting through any substantial change. That substantial change goes on is a primary datum of experience.

REVIEW QUESTIONS

1. In what sense can we say that there are contraries in substance and in what sense not?
2. Why can matter and form be considered essential principles of motion?
3. Why is privation an incidental principle of motion?
4. Compare privation and matter.
5. Why can matter be said to be a potential and form an actualizing principle?
6. Prove that primary matter is purely potential.
7. How does the question of the purely potential character of primary matter relate to the problem of whether substantial changes occur?
8. Give and explain two nominal definitions for primary matter.
9. Why would there be a tendency to confuse matter and privation?
10. Prove that matter has an appetite.
11. Why is matter the fundamental reason for mobility in our world?
12. How do the three principles of motion found in Aristotle solve the problem of Parmenides?
13. Why is it impossible to get direct observation of primary matter?
14. In terms of primary matter and substantial form, what do we observe when we apprehend the mobile world with our senses?
15. Explain Aristotle's two analogies to form.

PROBLEMS

Comment on the following passages in the light of the present chapter:

I

"For we hold that substantial forms do not have contrariety, strictly speaking, but in the wide sense of privative opposition which is the principle of contrariety. Nor does it follow that the old form is indeed a principle because it is positively contrary to the new form. For it may be argued that the old form is not opposed to the new except by reason of the privation annexed to it, not by reason of any special contrariety, for each has an indivisible character since it is a substantial form conferring first act; and thus it does not found the opposition of greatest distance [as contraries like white and black are at the greatest distance] since what is first does not vary [like contraries] according to more or less. Also the old form cannot be a principle in an essential and formal way of the new production of a natural thing, because it is essentially required to the production of one form that it come not from another but from non-being...

John of St. Thomas, *Natural Philosophy*[33]

II

"Next we must state what the difference is between coming-to-be and 'alteration' — for we maintain that these changes are distinct from one another.

"Since, then, we must distinguish (a) the substratum, and (b) the property whose nature it is to be predicated of the substratum; and since change of each of these occurs; there is 'alteration' when the substratum is perceptible and persists, but changes in its own properties, the properties in question being opposed to one another either as contraries or as intermediates. The body, e.g., although persisting as the same body, is now healthy and now ill; and the bronze is now spherical and at another time angular, and yet remains the same bronze. But when nothing perceptible persists in its identity as a substratum, and the thing changes as a whole (when, e.g., the seed as a whole is converted into blood, or water into air, or air as a whole into water), such an occurrence is no longer 'alteration.' It is a coming-to-be of one substance and a passing-away of the other — especially if the change proceeds from an imperceptible (either to touch or to all the senses), as when water comes-to-be out of, or passes-away into, air: for air is pretty well imperceptible. If, however, in such cases, any property (being one of a pair of contraries) persists, in the thing that has come-to-be, the same as it was in the thing which has passed-away — if, e.g., when water comes-to-be out of air, both are transparent or cold — the second thing, into which the first changes, must not be a property of this persistent identical something. Otherwise the change will be 'alteration.' Suppose, e.g., that the musical man passed-away and an unmusical man came-to-be, and that the man persists as something identical. Now, if 'musicalness and unmusicalness' had not been a property essentially inhering in man, these changes would have been a coming-to-be of unmusicalness and a passing-away of musicalness: but in fact 'musicalness and unmusicalness' are a property of the persistent identity, viz., man. (Hence, as regards man, these changes are 'modifications'; though, as regards musical man and unmusical man, they are a passing-away and a coming-to-be). Consequently such changes are 'alteration.' "

Aristotle, On Generation and Corruption[34]

NOTES TO CHAPTER VI

1. Cf. John of St. Thomas, Curs. *Phil., Phil. Nat.,* I. P., Q. II, a. 2, ed. Reiser (Turin, 1930), II, 43.
2. Com. on the Phys., Bk. I, les. 11, 9; On the Power of God, q. 3, a. 2.
3. Phys., Bk. I, ch. 7, 190b, 19-28; Com. on *the Phys.,* Bk. I, les. 13, 3.
4. Prin. of Nat., 9; Phys., Bk, I, ch, 8, 191a, 33–191b, 9.
5. *Phys.,* Bk. I, ch. 7, 190b, 20-23; *Com.* on the Phys., Bk. I, les. 13, 2.
6. Com. on the Phys., Bk. I, les. 14, 5.
7. *Phys.,* Bk. 1, ch. 190b, 28-191a, 3; Com. on the Phys., Bk. I, les. 13, 5.
8. *Phys.,* Bk. I, ch. 9, 192a, 20-21; Com. on the *Phys.,* Bk. I, les. 13, 4.
9. Com. on the Phys., Bk. V, les. 1, n. 1244; Sum. cont. Gent., Bk. I, ch. 71.

10. Com. on *the Phys.,* Bk. I, les. 12, 6; les. 13, 3; les. 13, 5; *Prin. of Nat.,* 9.
11. Summa Theo!., I, q. 77, 1, reply 2; Com. on *the Phys.,* Bk. I, les. 14, 8; les. 15, 11.
12. On Truth., q. 3, a. 1.
13. Com. on the Met., Bk. VII, les. 3, nn. 2442-2443; Com. on the Phys., Bk. I, les. 15, 11.
14. Com. on *the Phys.,* Bk. I, les. 15, 3; Com. on the Met., Bk. VIII, les. 1, n. 1687; Bk. VII, les. 6, n. 1388; Summa *Theol, I,* q. 7, a. 1; I, q. 12, a. 1, reply 2; I, q. 77.
15. Com. on On Gen., Bk. I, les. 10; Summa Theo!, I, q. 7, a. 2, reply 3; I, q. 66, a. 1; I, q. 115, a. I, reply 2; Sum. con. Gent., Bk. 2, ch. 43; On the Power *of God,* q. 4, a. 1; On *Spiritual Creatures,* ch. 8; Quod., q. I, art. 6; cf. H. Renard, The *Philosophy of God* (Milwaukee, 1948), 2nd ed,, p. 27.
16. Com. on the Phys., Bk. I, les. 15, 11; cf. also Phys., Bk. I, ch. 9, 192a, 31-33.
17. Com. on the Met., Bk. VII, les. 2, n. 1285; cf. also Met., Bk. VII, ch. 3, 1029a, 19-21.
18. Phys., Bk. I, ch. 9, 191b, 35-36; Com. on the Phys., Bk. I; les. 15, 2; Com. on the *Met.,* Bk. II, les. 4, n. 329.
19. Com. on the Phys., Bk. I, les. 15, 8.
20. Ibid., Bk. I, les. 15, 10.
21. Phys, Bk. I, ch. 9, 192a, 22-23; On Truth, q. 22, 1, reply 3.
22. Sum. cont. Gent, Bk. III, ch. 22.
23. Com. on the Phys, Bk. I, les. 13, 4; Prin. of Nat, 17.
24. *Phys.,* Bk. I, ch. 2, 184b, 25 ff.
25. *Ibid.; Com.* on *the Phys,* Bk. I, les. 6, 2.
26. *Phys.,* Bk. I, ch. 9, 191a, 35; Com. on *the Phys,* Bk. I, les. 15, 2.
27. Com. on the Phys, Bk. I, les. 14, 8.
28. *Phys.,* Bk. I, ch. 8, 190a, 25-191b, 20; Com. on Phys, Bk. I, les. 14, 8.
29. On the Soul, Bk. II, ch. 1, 412b, 19-20.
30. Prin. of Nat, 3.
31. On the Soul, Bk. II, ch. 1, 412a, 22-27.
32. Cf. Chapter VIII.
33. Curs. Phil, *Phil.* Nat, I. P, Q. II, art. 2, ed. Reiser (Turin, 1930), II, 45.
34. Ch. 17.

CHAPTER VII

THE SUBJECT OF THE SCIENCE OF NATURE

I. PROBLEMS PRELIMINARY TO OUR SCIENCE

a. *Problems So Far Discussed*

In previous chapters we have seen that the first principles upon which all mobile being depends are three: the first subject or primary matter, the substantial form determining that matter, and the previous privation of that form. These are truly necessary and universal principles of nature, and since they exist in the natural or physical world, it is possible to construct a certain knowledge of nature in terms of its causes and principles.[1] On the basis of the preceding three chapters taken in whole or in part, a science of nature, in the Aristotelian sense of the word science, can now be begun. Everything presented so far in these pages is really a prelude to that science.

b. Two *New Problems*

Our next task is to determine more precisely what the subject of our science is and what are the middle terms by which demonstrations are made concerning the subject.[2] Every science has a distinctive subject; every science, by the use of middle terms that represent causes, demonstrates the properties of its subject. What is our science of nature about and through what kinds of causes are demonstrations made regarding our subject? These are the two questions that Aristotle asks and answers

in Book II of his *Physics* after establishing, in Book I, that there are first principles in our mobile world. The problem of the subject of our science and its middle terms of demonstration occupy the next four chapters of this book.

Like the material considered so far, even the two questions raised in Book II of the *Physics* do not push us past the threshold of a truly scientific knowledge of nature. No demonstrations have yet been made in this science; and until we know precisely what the subject of our science is and what are the middle terms by which we can demonstrate the properties of this subject, no demonstrations in natural science are possible.

II. EXAMPLES OF NATURE AND ART

a. Two *Lists of Examples*

Natural things, that is, those things whose principle is nature, constitute the subject of natural science.[3] But what is nature? In order to define nature and defend our definition, it will be best to use division, the way to definition; in other words, an understanding of nature will here be approached by contrasting nature with its opposite. That opposite is art.

Some things come to be by nature and some by art. If we can establish the difference between these two kinds of becoming, we will be on the road to an understanding of what nature is, and when we understand this we will know better what our subject is, i.e., the things that come to be or are by nature.

Let us first of all list several things that come to be by nature and several that come to be by art:

Nature: (1) trees naturally grow; (2) iron rusts by nature; (3) silver tends to fall of its very nature; (4) sheep naturally grow wool; (5) by nature, wood burns.

Art: (1) a house is a work of art; (2) a sentence is the product of the art of grammar; (3) Michelangelo's statue of Moses is an artefact; (4) human art makes woolen clothes; (5) card-playing is an art.

b. Etymology of *"Nature"*

In the etymological meaning of the term, "nature" is derived from the same Latin root as our English word "nativity."[4] In the first imposi-

tion of the term, nature has to do with the process of being born. Our English word "physical" comes from the Greek word meaning birth,[6] so that natural and physical are taken in this book as synonymous terms. Another term for natural is mobile, and since everything material is mobile,[6] the word mobile can be added to our list of synonyms.

What is born comes to be from within a parent. A parent has within itself an intrinsic principle for producing its like. By an extension of the term, nature came to designate an intrinsic principle for originating motion, whether in the living or the lifeless world.[7]

c. *Meaning of Nature*

If we inspect the two lists of examples given before, we will see that all things in our first list (those whose origin is nature) have a very striking resemblance, and in this respect they differ from all works of art. What comes to be by nature has within itself a principle of motion and of rest; what comes to be by art does not have an intrinsic principle of this kind; its reality as a work of art is imposed upon it from the outside, namely, by the human mind.[8]

This difference can be seen very strikingly by considering the growth of a tree. A living tree has within itself a principle of motion, such as a power to grow, to repair itself when damaged, and to produce seeds. It is not simply the algebraic sum of forces acting upon it from the outside. Even though such outside forces are necessary if the tree is to grow or reproduce itself, the tree has something from within. When this intrinsic principle is gone, as in a dead tree, all of the outside forces like the sun, water, and carbon dioxide, which previously had fostered the growth and other activities of the tree, are now powerless to make it behave as a tree. An acorn planted in the proper soil will naturally tend to grow into a giant oak tree; but if the acorn is dead to begin with, i.e., if it does not have within itself a principle of life, the best soil in the world will not make it grow a fraction of an inch.

d. *Nature Contrasted With Art*

Although an acorn will tend to grow into an oak tree, the wood in the tree will not naturally tend to form a house. To make a house, man must operate on the wood from the outside. To make a house, man must cut the wood, smooth it, place the boards in proper relationship to each other, and fasten them together. Thus in art, the principle of

motion is not within things; the principle of making in the case of a work of art lies in human reason?

By its own nature, iron rusts in the weather; rusting is not a work of art. But a sentence is clearly a work of art, for never by their nature would sounds take the arrangement, make the pauses, and form the inflections which the human art of grammar gives to them. With all of the sounds it makes, no animal ever comes close to forming a sentence.

Silver dropped from a height above the ground will, by its very nature, tend to fall toward the ground;[10] but Michelangelo's "Moses" had to be made or moved by something outside nature, namely, human reason. In a similar way, the growth of wool results from a principle within the sheep; but a woolen suit or dress is a product of human reason.[11]

181. SOME OBJECTIONS TO OUR CONTRAST

a. *The Difficulties Stated*

En route to our definition of nature, it has been instructive to divide nature from art and to make the induction that what comes to be by nature has its principle of motion within itself, whereas a product of art has its principle in human reason. However, there are several difficulties which indicate that our induction may not be a good one.

In the first place, there are surely instances where art and nature cannot be distinguished. If you found three pebbles arranged in the form of a right triangle on a college campus, it would certainly be possible to attribute their positions to natural circumstances. But they could also have been arranged by an eager student interested in the Pythagorean theorem. In cases of this sort, art and nature appear indistinguishable, and it would look as though our distinction between them is not supported by experience.

As a second objection, by attributing to nature an intrinsic principle of motion, it would appear as though we are attributing too much spontaneity; it might seem as though we are allowing nature to do things without the need of an external cause. Surely the iron would not rust except under the action of the rain and the atmosphere, and the sheep would not grow its wool without extrinsic causes like the grass it eats, the air it inhales, and the energy of the sun which provides a proper temperature. To view natural things as invested with an internal principle of motion would almost appear to be claiming that what is natural is self-moved or self-caused.

As a final difficulty, art also would appear to have a principle of motion within itself. A woolen garment will become worn and tattered from use. A house, over the years, will tend to become run-down. In the course of time, many great works of art have deteriorated and required periodic restoration. Did not "Venus de Milo" lose her arms? Hence it might seem that art, as well as nature, has a principle of change within itself.

These objections must be successfully met if our division of nature and art is a good one and if our division can lead to the inductive knowledge that nature has within itself a principle of motion while art does not. Such inductive knowledge, if true, will be included in our final definition of nature, but it cannot be true if our objections hold.

b. The *Difficulties Answered*

The first objection actually calls attention to a so-called borderland case. Admittedly there are many cases when it is humanly impossible to decide whether a given effect is the product of nature or of art; nonetheless, such a practical difficulty in human knowledge does not abolish the distinction in reality between the natural and the artificial. It means only that we do not have enough information to determine whether the object under investigation is one of nature or of art. There are many such borderline cases in various fields of inquiry. Thus biologists are unable to decide whether viruses are living or lifeless substances. But this does not mean that there is no distinction between life and non-life.[12] It means only that we are unable to muster enough information to discover how our distinction applies. A similar problem is met in classifying organisms intermediate between the plant and animal kingdoms. They must belong to one or the other, but facts are wanting to decide the issue. Finally, and this brings us to our present problem, it may be difficult and even impossible to decide in certain cases whether a given work is one of art or of nature. It would certainly be admitted by everybody that the Empire State Building is a work of art and the growth of sheep's wool a product of nature, so that between art and nature there is a clear and certain distinction in principle. But how this distinction applies in each particular case is another question. Our failure to apply this distinction in particular cases does not destroy the fact that there is a distinction to begin with and that, did we only know enough, we could find it.

In meeting the second difficulty, it can be countered that our notion of nature does not abolish the need for external causes — like grass and

air in the case of sheep and the weather in the case of the rusting iron. Such causes, however, do not enjoy an absolutely free play over their effect; the effect is not at the complete mercy of external causes producing it. The materials on which such causes operate will contribute from their own nature to what the final effects will be.[13] Thus, the same weather that will cause iron to rust will cause the acorn to grow. Why? Not because of the extrinsic causes — for they are the same, i.e., the same weather, in each case — but because of the material on which they act, the seedling in one case and the iron in the other. Each of these materials responds to the weather on its own terms and by its own nature. Each has a character within itself that, even when extrinsic causes are alike, makes the final effect to be different and distinctive.[14] Hot weather that will melt the snow may kill the grass underneath. This is not because of the differences among external causes — there is the same hot weather in both cases — but because the snow and the grass have an original character of their own and from within themselves. This inner principle is the nature of each. To sum up, then, our answer to the second objection, motion will always require an extrinsic cause of some sort.[15] But the material on which the cause works reacts to that cause according to its own inner principle of motion, i.e., according to its own nature. To speak of nature is to speak of the original, intrinsic character possessed by each kind of mobile being.

Lastly and by way of approach to our third problem, it should be pointed out that a work of art is never pure art. There is always some natural component in the work: there is the lumber in the house, the wool in the garment, the marble in the statue. The artist in our usual meaning of the term art invests this natural component with a pattern or character that it would not assume when left to the forces of nature alone.[16] It is this natural component which contains within itself a principle of motion or change.[17] Thus, a work of art undergoes change not because it is a work of art but rather because of the natural component on which the artist has worked. Garments tear not because they are garments but because they are woolen; given the same causes, each garment tears in different ways depending on the material of which it is made. Houses are attacked by termites not because they are houses but because they are made of lumber. In the case of a statue, "Venus de Milo" lost its arms not because it was a statue but because it was made of marble.[18]

Further objections might be alleged against our division of nature from art on the basis of modern physics with its making of new kinds

of atoms and on the basis of modern genetics with its making of new strains of living things. Is plutonium, for instance, a work of art or of nature? Although such objections really pertain to special branches of natural science, they must be taken up in this introductory book because of their contemporary importance. However, such consideration must be postponed until the definition of nature has been secured and until the relation between nature and art can be more precisely formulated.

IV. OUR DEFINITION OF NATURE

a. *The Explanation of the Definition*

"Nature," according to Aristotle and St. Thomas, "is the principle of motion and of rest in that to which it belongs essentially and primarily and not accidentally."[19] This definition is an expanded version of the previous insight into nature as an intrinsic principle. Because nature does not belong to any of the categories, and because real definitions can be given only for things falling into one *of* the ten categories, the foregoing formulation is only a nominal rather than a real definition. Each part of it must now be explained.

Nature is a principle. This means that nature is a source of something. It is related to motions which flow from it as cause is related to effects.

It is a source or principle of motion — of the rusting of iron or the growth of a tree or the production of wool by sheep.

It is also a principle of rest.[20] A stone, dislodged from a mountainside, falls by nature and, when it reaches the valley, is at rest by nature. In the latter case, to be at rest is the way in which its nature reacts to external circumstance. Iron, lying on the surface of the earth, is at rest there by nature; a dog or a cat when asleep is also naturally at rest.

Nature is in the thing to which it belongs, and in this way nature differs from art. In the light of the example in the previous paragraph, the principle of the stone's motion and of its rest is in the stone itself; under the same circumstances which bring about the motion of the stone, a twig might remain immobile. In kindred fashion, causes which produce a violent agitation of the air might leave a stone completely at rest. In each case, where extrinsic causes are alike, the difference in motions or between being moved and being at rest depends on the inner character, the intrinsic principle, the very nature of the stone, the twig, and the air.[21] Art, on the other hand, has its principle from outside the thing made or done.

Nature is in a thing essentially. It is part of the very constitution of the thing in question. There are men who are five feet and men who are six feet tall. Such a difference is accidental to their nature. This nature is essentially to be a rational animal. For copper to be shaped into a roof or a water-pipe is accidental to copper; what is essential to it are the principles of those properties studied by chemistry and physics, the charge on the copper, its valence, specific gravity, etc.

Nature is¿a thing primarily or properly.[22] To be in a thing primarily is to be there by reason of the whole of that thing and not by reason of its parts. Thus, man has reason primarily and taking his nature as a whole; he has fingers by reason of his parts. Man has weight not because he is rational but because he is mineral, having a physicochemical constitution. Weight is essential to man; so indeed are fingers. Neither of these is accidental to man, but neither of these belongs to man primarily or properly. A primary characteristic is peculiar to the particular species to which a thing belongs, like reason in the case of man. We do not know the natures of things in a definite way until we have attained to their primary or proper characters. Just as reason is primary in the case of man, *so for* example is the specific bark of a dog or rather the principle of which barking is a sign; other characteristics that are signs of primary principles include the peculiar atomic structure of each kind of element, specific gravities, boiling points, etc. Because of the difficulty in knowing what is primary or proper in things, we often use the terms nature and natural for any essential intrinsic characteristic even though that characteristic is not primary. Thus we say that man walks by nature or naturally even though he does so because of the genus to which he belongs and not because of what he has primarily. To know what is essential to a thing but not proper to it is to know its nature in only an imperfect way.

Nature is not in a thing accidentally, and in this respect what is by nature is contrasted with what is by chance. Freaks in the material world like storms or tidal waves, or monstrosities like blind cows or crippled dogs are chance events. They are disorders. They are accidents of nature but not nature in the strictest sense of the term.

b. *Is Natural Motion Relative?*

The accidental or incidental occurrences in the physical world will be the subject of a rather long discussion later on.[23] But one kind of incidental relationship, if mentioned here, may considerably help to

clarify our definition of nature itself. In order to illustrate the point at issue, let us imagine a man walking backward at four knots on a ship that is moving forward at four knots. With respect to the ship, the man is moving; but with respect to the harbor he has just left behind, he may be said to be immobile. It would look as though our definition of nature is relative, in the sense that motion depends upon our point of view. From the ship, one report of the man's motion will be given, and he will be said to be in motion, while from land, he will be said to be at rest. If motion is relative in the sense of being dependent on our viewpoint, so is the principle from which the motion comes, and our definition of nature will thus turn out to be almost useless in the study of the physical world.

A mathematical approach to the physical world, with its interest in measure and number, may well be unable to determine whether the man on our ship is moving or not; it may well be inadequate for the task of determining whether there is any fixed principle intrinsic to things. An approach of this kind may prevent us from deciding what is intrinsic and what is extrinsic. A physical or natural approach to our universe, however, can rescue us from the relativity implicit in the mathematical approach. It can truly be argued that the man is performing a motion natural to him, namely that of walking. This is something absolute. It is accidental that he is walking on a ship, and it is also incidental that he should be walking on something immobile, if there really is such a thing. Much the same problem would be met if we imagine a fish swimming in a sense opposite to the spinning motion of the earth at the same speed as the spin itself, and under such conditions that the fish, with respect to the earth, appears motionless. Once more a purely metrical approach to nature cannot determine whether there is any absolute motion going on and hence what principles of motion, if any at all, are in play. But the physical or natural study of nature can maintain that, no matter what relative velocities may be involved, the fish is engaged in its natural motion of swimming. This is something pertaining to the nature of fish. That the body of water in which the swimming goes on is itself in motion is accidental to the natural motion of the fish.

V. OUR DEFINITION AND MATHEMATICAL PHYSICS

a. *Natural Motion: An Intrinsic Perfection*

The last part of our definition of nature as something pertaining to

the essence of mobile being in distinction to what is accidental or incidental is of special significance. For it distinguishes motion that is natural to a thing (e.g., walking for a man and swimming for a fish) from motion that is accidental to the thing in question (e.g., the ship's motion in the case of the man and the motion of the water in the case of the fish). But examples like that of a man walking on a moving ship create a problem raised by Galileo[24] and by Newton.[25] Such cases have led to the notion that movement in nature is always relative, a mere change in external and mathematical relations without any intrinsic and natural modification in the things moved.[26]

Everything in nature has motions that are natural to it because everything in nature has something from within itself and is not explainable only in terms of outside causality.[27] But just as surely everything is caught up in a network of accidentally related motions. Everything on earth takes place on a sphere that itself is already in motion; but the motion of the earth itself is accidental to many natural motions on its surface.

According to the kinetic molecular theory, the tiny parts of a whole like a stone or an animal are in constant motion with respect to each other even when the whole appears to be at rest. Here again, the natural should be contrasted with the incidental. A stone or a sleeping animal is at rest when we take each of them as a whole; and the movement of their parts with respect to each other is only accidental to the rest characterizing the whole. Two different categories are involved in examples of this sort: one is where, the other is being situated. Motion in the order of posture, like that of the molecules in a sleeping animal, is accidental to the rest of the animal in the order of place. Such motion in posture no more by itself destroys immobility in place than the motion of our ship destroys the walking of our man.

b. *The Priority of Physical Knowledge*

A study of the physical world respecting only its mathematical or metrical aspects will always lead us into a relativity. Only a physical or natural analysis of material things can tell us how walking is opposed to swimming, what sleeping is as opposed to waking, how the falling of a heavy body near the earth differs in more than a mathematical way from the rising of a body.[28] All things in nature have natural motions because all natural things have something from within themselves, or else they are nothing. But it is appallingly difficult to find out for certain the natural movements of most of mobile beings undergoing local motion

in our tremendous cosmos. Our definition of nature can provide a framework within which special investigations will know what to look for; but it does not deduce the natures of things nor does it make the special investigation of nature any easier.[29]

e. *Mathematical Physics as Supplemental*

Given a previous physical analysis which discovers that material things will always have natures or principles of motion within themselves, the mathematical approach can help us acquire a more precise knowledge of these natural movements. Knowledge of velocity alone will not give us a knowledge of what it is to walk; but once we know what walking is, the rate of walking increases our knowledge of that physical reality which our science of nature is studying. Measurement of distances covered by a swimming fish will not tell us what swimming is; but the mathematical aspects involved in the swimming will tell us more about the physical event than we could know otherwise.

Mathematical physics can assist us to an ever finer knowledge of the mobile world; it can even help us to discover natures known to us only by their mathematical or metrical manifestations. But whatever its great excellencies, the mathematical approach to matter is not primary; no matter how many thousands of details we may learn from it, it is always supplemental to the few but extremely crucial principles of a non-mathematical and strictly physical study of the physical world. Mathematical techniques, unable to distinguish accidental motion from natural motion, cannot tell us what is natural and what is not; they can only enrich a knowledge of nature already reached in a physical way.

The last part of our definition, differentiating the essential from the accidental, is thus extremely crucial in the present-day problem of relating science in the ancient sense to science in the modern sense.

VI. ART AS AN OPPOSITE TO NATURE

a. *Art as a Product of Reason*

In contrast to what comes to be by nature, a work of art is always a product of human reason. There are several kinds of work which reason produces, and it would be valuable in another context to explore all of these kinds of art with the numerous divisions and subdivisions that such

a study would entail. However, art can be discussed here only insofar as it gives us greater insight into nature as we have just defined it.

Grammatical sentences are not found in nature. They are made by man; they are products of art. So too are logical definitions, logical propositions, and arguments; all such entities are made by human reason and can therefore claim to be works of art. A very common form of art is in the realm of mechanical tools — forks, hammers, automobiles, golf clubs, airplanes, television sets, and pressure cookers; the works of mechanical art, though produced by the mind, exist in the external world. Perhaps the most common meaning attached to the term art in contemporary English is that of the fine arts — painting, sculpture, mosaic work, wood carving, etc.[30] We take art in the traditional sense of any product made under the direction of human reason.

b. *Art as an Imitation of Nature*

All art is an imitation of nature.[31]

Such an expression can easily lead to misunderstanding and must be carefully explained. To conclude that art is an imitation of nature does not mean that the artist copies or mimics nature like a mechanical camera. It does not bind the artist to report on nature with the algebraic detail of a mathematical physicist. As an imitation of nature, art cooperates with nature and completes it.[32] To view art as an imitation of nature is to find it as an extension and perfection of nature. This can be seen from several examples.

Art extends and perfects nature. A hammer is an extension or imitation of the human hand; without it, man would have to pound things together with his fists or use some other way of fastening what he now does by driving nails. An automobile is a development of man's natural power of locomotion; without it and without other means of transportation that would be equally a development of our natural locomotion, man would have to go about entirely on foot. Speech is natural to man, the rational creature, just as locomotion is natural to him as an animal; the languages he invents build upon that natural power of articulate expression; they enable that power to extend and perfect itself. As grammar is to speech, so logic is to reason. Logic perfects the rational power of man."

If, therefore, art is an imitation of nature, such a view by no means condemns the artist merely to make carbon copies of experience. The

artist develops and refines what nature provides in less perfect form. Even in the case of painting and sculpture, for example, the artist, by selection and emphasis, distills out meanings and values that are in nature, bringing into greater clarity and order the natural potencies that things have for being appreciated by us. Art imitates nature even in the fine arts by extending and refining what nature presents in grosser form.

c. *Arts Co-operating With Nature*

From what has just been said, there are grounds for concluding that every artist co-operates with nature, because he develops nature and perfects what nature incipiently provides. Yet there are certain arts that work with nature's tendencies in so intimate a fashion that we reserve for them in a special way the name of "arts co-operating with nature."[34] As usual, the difference between arts co-operating with nature and other kinds of art can best be seen by employing examples.

A rather obvious kind of an art co-operating with nature's tendencies is the art of medicine. Many sick people, even though they call in a doctor, would be cured by the natural therapeutic tendencies in all living things without professional assistance. In such cases, the doctor does no more than speed up the process of recovery. Health may thus be restored in a great many cases either by nature's own causality or by the causality of the art of medicine, both of which co-operate to the same result. Another art of a sort similar to medicine is the art of teaching. There are many things which a learner can learn for himself, and in such cases the teacher once more only accelerates the process. Here, in a manner similar to our example taken from medicine, a result, called knowledge in a learner, can be produced either by the nature of the human reason operating on its own unaided natural level or by means of the art of teaching. The same effect can thus be produced by either chain of causality.[35]

d. *Other Arts*

Unlike our examples in medicine and teaching, there are certain effects which nature could not produce. Our arts co-operating with nature show that the nature of a living thing can restore health by itself and that the nature of human reason can attain truth by itself. But nature does not build ranch houses or airplanes; it does not print

newspapers or install telephones. Such products require human reason. They are always works of art. But they do not work with nature in so intimate a fashion that they can properly be called, like medicine, teaching, or agriculture, arts co-operating with nature. These kinds of art using nature to produce something that nature would not produce alone are more properly art than an art co-operating with nature. The reason why these are more properly arts is this: they are always a work of reason and never the product of principles intrinsic to our natural world. It should be carefully noted, however, that arts using nature or "additive arts," if we wish to use this term, are alleged to be purer forms of art but not necessarily to produce a better product than that produced by arts co-operating with nature, such as medicine or agriculture. We should likewise note that there are borderline cases where it is practically impossible to determine whether an art is one which co-operates with nature or one which merely uses nature.

But whether co-operating with a nature which already has an intrinsic tendency to the same end as the art itself or whether engaged in some other kind of work, every artist is required to study nature in order to be a successful artist. The doctor first tries to find out how nature tends to promote healing and then helps nature to reach its end. He finds, for example, that nature produces antibodies to throw *off* various germs; he then gives injections of these antibodies to strengthen and help nature. As an artist, the teacher tries to find out how the human intellect operates and then aids that intellect by co-operating with its natural tendencies. Even the maker of the first knife and fork must have studied the human hand in some crude manner in order to respect its natural tendencies.

From another angle and on the part of the matter employed, art would be impossible if there were no nature to imitate. The builder of a bridge studies the laws of gravity, of stresses and strains, etc., and to the extent that he obeys — let us even say, in a wide sense co-operates with — these natural tendencies, he makes a successful product. The designer of an airplane is familiar with the laws of aerodynamics and, by obeying them, produces an airplane. Francis Bacon said that nature, to be commanded, must first be obeyed. By learning how nature can produce power and by respecting nature's tendencies, man has succeeded today as never before in harnessing matter to his own purposes.[36] All arts, co-operative and additive, thus imitate nature by perfecting and extending it and respecting and developing it.

VII. HAS HUMAN ART MADE NATURAL THINGS?

a. *The Problem of New Elements and Mutants*

Indeed, by virtue of his refined knowledge of both the lifeless and the living worlds, twentieth-century man has been able to make new kinds of things that do not naturally occur and yet, when made, seem as natural as many other things of experience or experiment. A number of elements that, as far as we know, do not occur in nature, have been synthesized by contemporary physics; and geneticists, by the use of X-rays, have produced mutants in living things, for example, fruit flies which do not naturally occur. Both the new elements and the new fruit flies seem to be natural things. They have within themselves principles of motion and apparently fulfill the meaning of nature previously defined and defended. But they are produced by man. Are they nature or art? Can man by his art make things that have, not from him but from within themselves, that principle of motion we term nature?

b. *The Modern Scientist as an Artist*

In order to approach this problem, let us recall two previous conclusions from the present chapter. First, nature has been characterized as an intrinsic principle of motion. Second, the artist has been pictured as an imitator of nature; and, when he merely assists nature toward an effect which natural causality could also produce, e.g., health, he can be called in a special way a co-operator with nature. With these two principles, our present difficulty can be met.

No matter how a thing comes to be, it can be said to be by nature as long as it has within itself a principle of change. To return to our example of medicine, it can again be observed that what a living thing tends to do under the influence of a doctor's art it also tends to do on its own; and it can likewise be repeated that a doctor studies how living things tend by nature to cure diseases in order to assist and strengthen these natural curative tendencies. Let us take a living thing, even a man, restored to health by an antibiotic after an infection; at least by the time the cure is effected, the person can be said to have health by nature. For nature was the principal cause of the healing; the doctor was only a co-operator. Let us assume that the person had such a type of disease that he would have recovered health without the doctor's aid, but only after a longer time and after suffering more inconvenience. The

doctor was an instrument, a co-operator, serving another and more important cause, namely the living thing, and the living thing itself, at least after recovery, is said to be healthy now by nature and through its own power. Nature is always the principal cause of health; the doctor can never be anything more than an aid to whatever life is still present in a sick person.

Now something similar may be alleged to take place in atom-building. The physicist finds out how nature operates in combining various subatomic particles to yield the elements we now know, and since every artist imitates nature more or less, the atom-building physicist takes advantage of nature's own tendencies by bringing particles into such positions that natural forces will take over to produce new elements. Like a doctor disposing a sick patient in such a manner that the natural therapeutic tendencies of the living thing can the better restore health, the physicist arranges nature in such a fashion that its natural tendencies will operate to produce new elements; moreover, like the recovered patient, a new element will have an intrinsic principle of motion even though it came about by art. Whatever has an intrinsic principle of motion has a nature.

In this respect, the physicist resembles artists who co-operate with nature, and in this respect too, the atom-builder conforms to the general requirement of all art that it study nature's laws so that, by obeying them, matter can be better exploited and made an ever more obedient servant of human purpose.

Our two principles used to show how atom-building, as an art, can bring about new things that can be said to be by nature, e.g., plutonium and neptunium, can also be applied to solve the problem raised by genetics. Such principles have application even to the new space satellites where man again, having found out how nature does things, becomes a co-operator with natural tendencies and forces that he must obey in order to command.

Nikita Khrushchev's proud boast that the man-made Russian satellites have shown that there was no need for a God to make the heavenly bodies reflected, for one thing, a common failure to see art as the ability to use law-abiding powers and tendencies already existing in nature itself. If there were no natures, moved as we shall see by a First Mover, there could be no art. For art, whether in the making of a grass hut or in the spectacular production of an orbiting space satellite, is always a derivative and secondary phenomenon.

VIII. MATTER AND FORM AS NATURE

a. *Matter as Nature*

Under different aspects, both matter and form can be called nature,[37] In a special way the matter that we have called primary and the form that we have termed substantial can be called nature. Primary matter can be called nature because primary matter is the basic source or matrix from which all physical things come to be. Because primary matter is in things, it is an intrinsic principle. It belongs essentially to all the things of which it is a part. Primary matter may even be said to be proper in the sense of our definition of nature. As a result of substantial change, primary matter has been made suitable or proper to the composite by reason of the form, and in this sense also it can be called nature. An obvious example of matter made proper to the composite mobile being is the body of man with all of the dispositions distinctive and proper to him alone. Our form makes our matter to be suitable or proper to our species, and so our matter is not only essential, as the definition of nature puts it, but even proper.

In a genuine sense, nothing is a more basic source of motion than primary matter. Of its essence, it is nothing but a potency or appetite for form. Always deprived of all forms other than the one it bears, the primary matter in any material substance is ever restless and ready to surrender the form it owns in order to take on another. The whole history of our cosmos is the struggle of primary matter seeking to perfect itself, as a later chapter will show. Surely matter has a right to be called nature. Primary matter is the intrinsic principle of change in all things.

b. Form as *Nature*

From another angle, form can be called nature too,[38] for it is form which gives to matter a character or determination. It invests matter with something original and specific, so that the various kinds of mobile beings differ among themselves principally because of their forms, which in each case give a different character to matter. Because it gives to matter a determination original and primary to the species, substantial form is more of a principle (a distinctive source for the activities proper to a given species of mobile being) than matter and, from this point of view, is more eminently nature than matter can be. Looking at our principles from the point of view of their coming into being,

form is the end of matter and, as that which is principally intended by nature, is nature in a more profound way than matter.

But in the last analysis it is matter, rather than form, which is the basic source of motion in our cosmos. It is matter rather than form which constantly breaks down the old in our experience and seeks out the new. Reason can show that forms exist also in an immobile world and not only in this one; what characterizes our mobile, natural world and is not present in this other and immobile world is matter. Forms in this world, including even the soul of man, achieve their perfection only by being in matter and subjected to motion.

Matter and form are both nature; and so our science of what exists by nature will be a science of things that are by matter and form. Natural mobile being in other words is really that which is constituted of matter and form. The composite of matter and form is not itself a "nature" but a thing that comes to be by nature.[39]

IX. SUMMARY

Our present chapter, opening a section of our book devoted to the subject of natural science and to the middle terms by which it demonstrates, contrasted nature with art and defined nature as an intrinsic principle of motion and rest. In comparing nature to art, it was shown that art imitates nature, finding out how nature does things and then assisting or strengthening nature; in some arts like medicine or teaching or agriculture, nature taken alone could attain the ends attained by nature plus art, and arts of this type are called arts co-operating with nature.

A correct understanding of the principle that art imitates nature enables us to deal with problems raised by the fabrication of new elements in the mineral world and new mutants among living things. Finally, it was seen that both matter and form can be called nature.

Natural being, or what exists by nature, is that which exists by matter and form. This is the subject of our science. It is a more precise way of saying mobile being. Mobile being is that whose principle is nature.

REVIEW QUESTIONS

1. What questions are treated in Book II of Aristotle's *Physics?*
2. Why do they occur in Book II rather than in Book I?
3. Give some examples of nature as contrasted with art.
4. What is the etymology of the term nature?

5. What is the basic distinction between nature and art?
6. Does our notion of nature make nature to be self-moving? Explain.
7. State and explain the definition of nature.
8. Show how a mathematical approach to nature makes nature relative, whereas a strictly physical study of the world can, at least in principle, avoid such relativity.
9. What is meant by natural motion as an intrinsic perfection?
10. How does a mathematical physics supplement a strictly natural study of nature? Give examples.
11. Explain how matter and form are nature.
12. What is the subject of natural science?

PROBLEMS

Comment on the following passages, one affirming, the other denying nature, using explanations provided in the present chapter:

I

"Natural things differ from the non-natural in so far as they have a nature. But they do not differ from non-natural things except in so far as they have within themselves a principle of motion. Hence, nature is nothing else but the principle of motion and of rest in that in which it is primarily and essentially and not accidentally.

"Into the definition of nature *principle,* and not something absolute, is placed as the quasi genus, because the name nature conveys the idea of a source. For because those things are said to be born which are generated united to a parent, as is clear among plants and animals, therefore the principle of generation or of motion is termed nature.

"Hence those thinkers are to be rejected who in their ambition to correct Aristotle's definition have attempted to define nature as an absolute something: claiming that nature is a force *innate in things* or something of this sort.

"*Principle and cause* are mentioned in order to show that the nature of all motions is not always a principle in the same way in the thing moved but in different ways as was said.

"[Aristotle] says of *motion and of rest* because things naturally move to their place and in a kindred fashion and even more naturally come to rest there. . . .

"He says in *which it is* to distinguish it [nature] from artificial things in which there is no motion except by accident. He adds *primarily* because nature, although it is the principle of motion in things composite, is not so primarily. Hence, that an animal falls down happens not from its nature **as an animal but from the nature of the dominating element.**

"Why he says essentially and not *accidentally* he explains later. . . . For it sometimes happens that some doctor or other is the cause of his own healing; and hence the principle of his own healing is in him, *but accidentally;* therefore the principle of healing is not in him as nature; for he cures not according as he takes medicine but according as he is a doctor; it happens that he is both a doctor and is cured; but he is cured only in so far as he is sick. And because they are accidentally conjoined, they are accidentally divided: for it may happen that one person be a doctor who heals and another person a patient who is healed.

"But the principle of natural motion is in a natural body which is moved in so far as it is moved; for in so far as fire has lightness it rises. Nor are they divided from each other so that one thing would be a body which rises and another a body which is light; but they are always one and the same. And as with the curing doctor, so with all artificial things. For none have within themselves the principle of their own making: but some happen from the outside, as house and other things which are produced by the hand; and some happen from an intrinsic principle but accidentally as was explained. And in this fashion it is stated what nature is."

St. Thomas, *Commentary on the Physics*[40]

II

"But we are so far from being admitted into the secrets of nature, that we scarce so much as ever approach the first entrance towards them. For we are wont to consider the substances we meet with, each of them, as an entire thing by itself, having all its qualities in itself, and independent of other things; overlooking, for the most part, the operations of those invisible fluids they are encompassed with, and upon whose motions and operations depend the greatest part of those qualities which are taken notice of in them, and are made by us the inherent marks of distinction whereby we know and denominate them. Put a piece of gold anywhere by itself, separate from the reach and influence of all other bodies, it will immediately lose all its colour and weight, and perhaps malleableness too; which, for aught I know, would be changed into a perfect friability. Water, in which to us fluidity is an essential quality, left to itself, would cease to be fluid. But if inanimate bodies owe so much of their present state to other bodies without them, that they would not be what they appear to us were those bodies that environ them removed; it is yet more so in vegetables, which are nourished, grow, and produce leaves, flowers, and seeds, in a constant succession. And if we look a little nearer into the state of animals, we shall find that their dependence, as to life, motion, and the most considerable qualities to be observed in them, is so wholly on extrinsical causes and qualities of other bodies that make no part of them, that they cannot subsist a moment without them: though yet those bodies on which they depend are little taken notice of, and make no part of the complex ideas we frame of those animals. Take the air but for a minute from the greatest

part of living creatures, and they presently lose sense, life, and motion. This the necessity of breathing has forced into our knowledge. But how many other extrinsical and possibly very remote bodies do the springs of these admirable machines depend on, which are not vulgarly observed, or so much as thought on: and how many are there which the severest inquiry can never discover? The inhabitants of this spot of the universe, though removed by so many millions of miles from the sun, yet depend so much on the duly tempered motion of particles coming from or agitated by it, that were this earth removed but a small part of the distance out of its present situation, and placed a little further or nearer that source of heat, it is more than probable that the greatest part of the animals in it would immediately perish."

John Locke, Concerning *Human* Understanding[41]

NOTES TO CHAPTER VII

1. Cf. Chapters IV-VI.
2. Com. on the Phys., Bk. II, les. 1, 1. Cf. also C. Taylor, "The Relation Between Book I and II of the Physics," Laval *Théologique et Philosophique,* VII (1941), 150-158.
3. *Com. on the Phys.,* Bk. I, les. 1, 3.
4. Com. on *the Met.,* Bk. V, les. 5, nn. 808-820.
5. A. Taylor, *Aristotle* (New York, 1955), p. 63; K. Reizler, Physics and Reality (New Haven, 1940), p. 60.
6. Com. on the Phys., Bk. I, les. 1, n. 3; Prin. of Nat., 5.
7. Sum. cont. Gent., Bk. IV, ch. 35.
8. Phys., Bk. II, ch. 1, 192b, 12-23; Com. on the Phys., Bk. II, les. 1, n. 2; Com. on the Met., Bk. VII, 6, n. 1381.
9. Com. on *the Met.,* Bk. XII, les. 3, n. 244.
10. On *Truth.,* q. 23, a. 3; q. 24, a. I.
11. Phys., Bk. II, ch. 1, 192b, 33 ff.; Com. on the *Phys.,* Bk. II, les. 1, 2.
12. Cf. Sr. Adrian Marie, "Viruses: Are They Alive" *The New Scholasticism,* XXI (1957), 297-316.
13. Sum. cont. Gent., Bk. II, ch. 22.
14. Com. on the Phys., Bk. II, les. 5.
15. Cf. *infra,* Chapter IX.
16. On Truth, q. 2. a. 5; On *the Power of God,* q. 6, a. 3.
17. Sum. cont. Gent., Bk. III, ch. 65.
18. Phys., Bk. II, ch. 1, 192b, 19-21; Com. on the Phys., Bk. I, les. 12, 11.
19. Com. on the Phys., Bk. II, les. 1, 5; Phys., Bk. II, ch. 1, 192b, 21-23; cf. J. Weisheipl, "The Concept of Nature," *The New Scholasticism,* XXVIII (1954), 379-408.
20. On *the Power of God, q. 6,* 5, reply 5; On *Truth,* q. 22, a. 1, reply 11.
21. Sum. cont. Gent., Bk. II, ch. 22.
22. The explanation of John of St. Thomas, Curs. *Phil., Phil. Nat.,* I. P., Q. IX, a. 1, ed. Reiser (Turin, 1930), II, 170 ff., esp. 173.
23. Cf. Chapter X.
24. Dialogue Concerning *the Two Chief World Systems,* trans. S. Drake (Berkeley, 1953), 186 ff.
25. *Mathematical Principles of* Natural *Philosophy,* transi. A. Motte, rev. *F.* Cajori (Berkeley, 1947), p. 7.
26. For the view of motion as a mere change of external relations, cf. Leibniz.- *Selections,* ed. P. Wiener (New York, 1951), p. 252.
27. This point is considered in my *Philosophical Physics,* (New York, 1950), p. 149 ff.
28. Cf. Eddington's analysis quoted in Chapter II, n. 39.
29. For the dependence of natural science upon experience, cf. Com. On the Sens., I.
30. For an excellent discussion of the division of the arts and of their interrelations, cf. B. Mullahy's "The Nature of the Liberal Arts," *The New Scholasticism,* XXIII (1949), pp. 361-386.
31. *Exposition of the Post. Anal.,* Prologue.

32. On Truth, q. U, a]. ‹julnina *Theol.,* I, q. 117, a. 1; Com. on the *Phys.,* Bk. II, les. 13, 4
33. Cf. John of St. Thomas, The Material *Logic of John* of St. Thomas, I. P., Q. I, a. 1. Transi. Y. Simon and^ others (Chicago, 1955), pp.
34. Cf. Phys., Bk. II, ch. 1, 192b, 23-33.
35. On *Truth.,* q. 11, a. 1; Sum. cont. Gent., Bk. II, ch. 75.
36. Unrelated to nature's first principles, modern science is but a preparation for such practical achievement. Cf. my Philosophical *Physics,* ch. 5.
37. Cf. Phys., Bk. II, ch. 1, 193a, 27-28; Com. on the Phys., Bk. II, les. 2; 1-2; Com. on the Met., Bk. V, 1. 5, n. 821.
38. Phys., Bk. II, ch. 1, 193b, 7-12; Com. on the Phys., Bk. II, les. 2, 3-7; Com. on the *Met.,* Bk. V, 1. 5, n. 821.
39. Com. on *the Phys.,* Bk. II, les. 2, 4.
40. Translation mine. *Ibid.,* Bk. II, les. 1, 5.
41. Book IV, ch. 6, "Great Books of the Western World," XXXV, 334.

CHAPTER VIII

THE PHYSICAL AND THE MATHEMATICAL

I. THE PROBLEM

a. Some *Historical Circumstances*

Equipped with the conclusions from Chapters IV, V, and VI that there are first principles in the mobile world, the chapter just ended provided a nominal definition of nature. We can now get a better grasp of the subject of our science. That subject is whatever exists by nature, whatever has within itself a principle of motion, whatever has matter and form. As a transition to the next major problem, concerning the kinds of middle terms employed in our science,[1] it is logical to ask at this point how the physical approach to natural things differs from the mathematical. This is an important question that will focus even more sharply the subject of our science and enable us more clearly to analyze our middle terms. Aristotle found it important to discuss the relation of physical and mathematical knowledge because his predecessors, the Pythagoreans and Plato, approached nature from a strictly mathematical point of view. It is hardly necessary to mention the importance of this subject in our own day. The acceptance of a purely mathematical approach to nature may never have looked more attractive than now.

b. *Problems of Principle*

This is not the first time in these pages that we have discussed this problem or proposed some aspect or other of the solution. However, with a better knowledge now than we had before concerning the subject

of our science, it will be valuable to look once more at the relation between physical and mathematical knowledges.

At first physical and mathematical sciences might seem to be the same type of thing, and ancients like Pythagoras and moderns like James Jeans have actually said they are.[2] Certainly they seem to be concerned with tire same things. All material reality has figure, for example; and it would look therefore as though geometry has a stake in the study of the material or mobile world. Everything material can likewise be numbered, and in this respect arithmetic too appears to have some sort of claim as a science of matter. In summary, if everything in the natural world is of interest to the natural scientist, then it would look as though mathematics, when studying figures, solids, and numbers in the material world, would at least be a part of physics if not more.

II. THE DIVISION OF SCIENCES BY OBJECTS

a. *Order in Material Structure*

However, sciences are distinguished from each other not in terms of the reality studied but in terms of objects.[3] Hence, if there is a difference between a mathematical and a physical study of the material world, such a difference must be based on a difference in objects. It may well be that mathematics and natural science in some way bear upon the same matter; but, as we previously saw, they look upon matter from two distinctive levels. Although they may both deal with the same thing, **g.**, the roundness of an orange, they consider the thing — and in reality it truly is one and the same thing — as two different objects. The mathematician is absorbed in the character of being round without regard to the physical or sensible matter in which this character is found, i.e., the colored, edible, semitropical fruit we call an orange. On the other hand, the natural scientist studies the character of being round precisely as the termination of sensible matter; for him, the figure of an orange is not a termination freed from the sensible qualities which it bounds.[4]

The difference we have just stated in the two different approaches to an orange's character of being round must be cast in a more general form so that a solid framework can be laid for distinguishing mathematical and physical sciences. Analysis will show that the difference between the mathematician and the physicist is a genuine difference of objects, each independent and each capable of a distinct representation by the human intellect.

The accidents of a material substance come to it in a definite order; this need not be temporal, but it is always an order of real dependence of one thing upon another.[5] The first characteristic of material substance is quantity, the accident by which substance is spread out with parts outside of one another. Without quantity as providing an extension to substance in space, material things would collapse into a point.[6] Moreover, quantity is presupposed by any other material accident inhering in substance. There could be no color, for instance, unless it were spread out on a surface; color that existed indivisibly and without being extended would be invisible. Quality thus presupposes quantity in order to exist, as quantity itself presupposes a substance in which it inheres. Once there are qualities like color or size, accidental motion can take place, as in the reddening of an apple or the growth of a dog. Such accidental motion presupposes quality, which presupposes quantity, which presupposes substance. Hence, in the structure of material things based upon the dependence of one thing on another, substance comes first, followed by quantity, then qualities, and finally the motions of the material thing.

b. *Realistic Independence of Scientific Objects*

Probably no principle is more important than the one just proposed for dividing sciences from one another while preserving to each a realistic basis. In order to apply the principle more fruitfully to our problem of relating physical and mathematical knowledge, it should first be proposed that what is prior to something else in the structure of things can be understood without that something else, but not conversely. Man, for instance, is presupposed by scientist, and man can be understood without reference to scientist. But, on the other hand, scientist cannot be understood without reference to man. The reason for this is that there must be a man before there can be a scientist, and so human nature, a prior reality, can be understood without understanding scientist, a posterior reality. To repeat the general principle we are proving, prior things do not depend on posterior things and can be grasped without understanding these posterior things; but posterior things, depending as they do on prior things, cannot be understood without understanding these prior things. In St. Thomas' own language:

> For it is manifest that posterior things are not involved in the understanding of prior ones, but just the opposite; hence the prior can be understood without the posterior, but not conversely. For instance, *animal* is clearly

> prior to man and *man is* prior to *this* man: for man is related by way of addition to *animal* and *this* man by way of addition to man; and on this account, man is not involved in the definition of animal, nor Socrates in the definition of man; hence animal can be understood without man and man without Socrates and other individuals.[7]

The foregoing examples throw light on the principle that things prior in nature to other things can be understood without understanding these other and posterior things. However, the posterior cannot be understood without the prior. If material reality involves the order of substance plus quantity plus quality plus the accidental motions of matter, it can now be argued that substance can be grasped without the understanding of quantity, and quantified substance can be understood without quality and motion; but accidental motion cannot be understood without quality nor quality without quantity nor quantity in turn without substance, since there is a dependence in being of motion on quality, of quality on quantity, and of quantity on substance. Where one thing depends on something else as part of its being our concept of that thing must include that on which it depends.

c. Two *independent Sciences*

Understood without quantity and quality and motion, substance can be studied in metaphysics or natural theology. Substance and quantity, in turn, can be understood without reference to sensible quality and its motions; and such quantified being is the subject of mathematics.[8] The science of nature, in its concern with motion, must represent in the conception of its object the qualities and quantities and substance which motion presupposes and without which it cannot be conceived. Hence, the science of nature takes into account all four members of the hierarchy.

From the foregoing paragraph, it is worthy of note that mathematics, as a strict science, considers the first two members in the fourfold hierarchy in matter; that is, mathematics considers quantified substance. The subject of mathematics in its scientific form can thus be seen to be a conceptually independent object of investigation. It can be understood without those sensible qualities and their motions which make things natural or physical. That is to say, because sensible qualities and their motions are logically posterior to quantified being or quantified substance, quantified substance can be understood without them. Neither motions nor sensible qualities are intrinsically necessary for mathematical science.

In the hierarchy of substance plus quantity plus quality plus the motions of matter, the mathematician considers only part of the fourfold structure, i.e., quantity and substance. Hence, contrary to an opinion sometimes expressed that mathematics does nothing but construct idealizations, it can be counterargued that mathematics in its best and truly scientific sense does not project anything into reality. It leaves something out. That is, it omits reference to the qualities and motions of things which make mobile being to be mobile or natural or physical. In this light, mathematics considers its object in independence of the sensible qualities where it enjoys the only real existence it can claim. Having a distinct object, mathematics is a science distinct from the science of nature.

Mathematics does not warp the real. As St. Thomas Aquinas remarks:

> Even though [mathematical realities] are not abstract in their existence, mathematicians, when abstracting them for understanding, do not falsify. For they do not assert them to exist outside of sensible matter — this would be a falsification — but they consider them without considering sensible matter, which can take place without falsification. In a similar way, one can consider whiteness without considering music and truly so, even though they both belong to the same substratum: yet it would not be a true consideration if one asserted the white to be non-musical.[9]

By differentiating mathematical and physical science, we are going to learn more about our own science of nature. Therefore, it might be of value to linger on the foregoing analysis with just one more example. Let us imagine first an orange falling from a tree and, at least because of its fall, having the fourfold structure of material realities. Because of the interdependence of the four members as previously explained, it is possible while being realistic to relinquish our regard for the motion of the orange and consider only its qualities, quantities, and substance. It is possible also to take a second step, i.e., to turn from a consideration of the sensible qualities, the colored, the sweet, the hard, and other characteristics which our external senses can grasp; and what is now left, but in a still realistic setting, is the spherical outline in the order of quantity, together with the substance as the subject of that quantity. Something similar to this process of elimination takes place in the abstraction performed by the mathematician who considers only the prior two structures in our fourfold hierarchy of material things without taking into account the posterior and sensible structures.

d. *Mathematical and Physical Science*

The science of nature, on the other hand, takes into account the

whole fourfold hierarchy we have been discussing — beginning with accidental motions and moving inward to the natures of the qualities, and quantities, and finally the substances themselves. Thus the science of nature studies quantity but only insofar as it is related to motion, whereas mathematics, putting change out of consideration, cannot invoke motions to gain an insight into its object.[10] It may truly be concluded, then, that the mathematician penetrates quantified being as known through its own character and by its own evidence, while the student of nature considers quantified being only as related to motion. The object of natural science is thus distinct from that of mathematics; and mathematics, in turn, because it cannot deal with motion as such, is a science distinct from the science of nature.

III. THE STATUS OF MATHEMATICAL PHYSICS

a. *Mathematical Physics Concerns Mobile Being*

If our earlier analysis is valid, studies that we usually call modern science, e.g., physics, chemistry, biology, etc., do not have a truly physical object distinct in principle from the object studied by our science of nature. Our general science, it was proposed, reveals knowledge of mobile being only at a general level; the modern approaches to nature enable the mind to penetrate that same object more deeply.

In contrast to studies that are more qualitative like parts of biology, chemistry, and mineralogy, mathematical physics involves knowledge of a special type and hence must be accorded special treatment here. Mathematical physics, or more generally applied mathematics, should be distinguished on the one hand from purely mathematical knowledge and on the other hand from purely physical or natural knowledge. In order to grapple with this question, it is necessary to return to our relations of the prior and the posterior in material things and in our knowledge of those material things.

The mathematical physicist, even when examining the quantified properties of beings in our physical world, e.g., the charge on the electron, the rate of falling bodies, the velocity of light rays, the gravitational pull on a satellite, cannot represent his object without representing mobile being. The pure mathematician can do so; he can conceptualize his object without representing the sensible quality and the motions that are posterior to it. But the mathematical physicist or any other applied mathematician, e.g., a chemist computing equivalent weights, cannot

think about his object without making the mobile being of our own science an intrinsic even if subordinate part of his thought.11 As the concept animal is included in that of man, so the conceptualization of the entities studied by modern science requires the inclusion of mobile being as an essential, though shadowy, part of their concepts. The properties of electrons or of falling bodies are related to mobile being in general as the posterior is related to the prior; since mobile being in general is logically prior to properties dependent on motion. Hence, such posterior properties cannot be represented in our concepts without the representation, at least implicitly, of the prior concept of mobile being. By contrast to pure mathematics whose object is quantified being and whose scope is thus only a part of the fourfold structure of material being, mathematical physics is not interested, for example, in $s = \%gt^2$ as a purely mathematical judgment but as a law expressing the distance covered by freely falling bodies; and it is not interested in $e - 4.80 \times IO\text{-}10$ as an abstract equation but as a formula in electrostatic units for the charge on the electron. Mobile being is the term into which the propositions formulated by mathematical physics must ultimately be resolved.

b. *Mathematical Physics Is More Physical Than Mathematical*

Unlike mathematics which studies only quantified substance and thus leaves aside the qualities and motions of matter, mathematical physics takes account of the fourfold structure of material things. It employs mathematics not to get at quantified being but to penetrate sensible matter. Yet it differs from the science of nature because it demonstrates through mathematical and not physical middle terms. For example, if a wound is circular, it follows that it has a greater area than a straight-line figure with the same perimeter, and the reason (middle term) for this conclusion is a geometrical one, the very nature of a circle compared to a straight-line figure. The fact that in mathematical physics the middle terms or principles of explanation are mathematical enables us to understand how physics, since the time of Galileo, has made tremendous progress without a secure foundation in the natural and strictly physical principles we have been studying in this book.

But it should be remembered that the subject which mathematical physics, with its mathematical middle terms, seeks to explain is the physical, natural, mobile world. Mathematical physics terminates in physical knowledge; otherwise it would be pure mathematics. As physical

in aim but mathematical in means, mathematical physics may be properly regarded as a science intermediate between purely physical and purely mathematical knowledge. It is mathematical in form and physical in the matter it studies. Since its aim or final cause is to get at physical reality, mathematical physics is principally (terminative) physical knowledge; its main concern is to know not the mathematical but the physical. Because of this ultimate purpose to know the physical, mathematical physics is more physical than mathematical,12 and so, while it is important to distinguish mathematical physics from the purely mathematical, it is even more important to relate it in the proper and positive way to the unified science of mobile being, which begins with the most general principles and works down to as much detail as the progress of our dialectic and advances in our testing instruments will permit.

Since it is not pure mathematics but mathematics in an applied form, mathematical physics is concerned with quantified substance as found in its physical, sensible, natural, mobile existence. Mathematical physics is concerned with the forms and figures of nature, with its weights, velocities, and accelerations, with its times and spaces, its mechanical forces, electrical charges, and magnetic moments, with the wave lengths and densities in nature, with its constants of fission and of fusion. Mathematical physics wants to measure all of these; but what it reports is some characteristic of material things, some property or accident of mobile beings. Some kind of mobile being thus forms the object of mathematical physics. Its matter is physical, although its form is mathematical.

Because its material is physical, mathematical physics would logically presuppose some knowledge of the physical or natural world to which mathematics is applied. It can yield certain knowledge concerning physical things by invoking the necessary, though mathematical, causes operating upon these things or within them. Thus, the geometrical figure of the earth as circular, if not spherical, can be demonstrated from the kind of shadow which it casts upon the moon.

c. *Mathematical Physics as Terminating in the Science of Nature*

Although capable of achieving certitude by reason of its own mathematical principles, mathematical physics leaves the mind in an imperfect state. Since its purpose is to know nature, mathematical physics is physical in its term and hence physical in its aim; mathematics is only a tool or

a means. In a synthetic science of nature, mathematical physics thus presupposes the more general or philosophical physics which we are trying to elaborate.

Pure geometry studies form and figure but not as they exist in sensible matter; rather it abstracts the form and figure from such matter, g., the spherical form from an orange and the wave form from a vibrating string. However, the mathematical physicist studies such forms as they exist in sensible matter; unlike the pure mathematician, he is reporting on the same kind of world as the science of nature and thus, at the term of his study, he rejoins the science of nature. In a language that will be clarified in the next chapter, mathematical physics belongs to the same science as natural science in its material and final cause; but not in its formal cause (medium of demonstration), nor in its efficient cause (the mind measuring and performing mathematical operations).

Because general considerations of matter precede the special studies of our universe, the study of mobile being in a truly synthetic way should precede the investigation based upon specialized and precise techniques like measurement; knowledge obtained by measuring the mobile world is, as physical knowledge, a continuation of the same science that concerns mobile being in a more common and vague way.[13] Whereas the consideration of mobile being in general bears upon the more common characteristics of material things, mathematical physics in view of its physical aim is more concerned with details.

Mathematics as such can be a science distinct from the science of mobile being, since substance plus quantity, the object of mathematics, does not make a necessary intrinsic reference to mobile being. But mathematical physics, as distinct from natural science, is distinct in a different manner; mathematical physics does make a necessary and intrinsic reference to mobile being which is its matter; it refines our knowledge of mobile being to a point where results can be stated in measure and number. Such refinement in knowing mobile being presupposes a knowledge of mobile being in general just as the posterior requires the prior, and the more perfectly a mind possesses a premathematical science of nature the better its total scientific knowledge of nature will eventually be. The more perfectly a mind knows mathematical physics the more perfect and proper will be its synthetic knowledge of the physical world.

d. *Mathematical Physics as Dialectical and as Scientific*

The ancients were aware of subjects quite similar to what we now

call mathematical physics. Subjects of this kind would be exemplified by astronomy, optics, and music, which were all analyzed by mathematical techniques.[14] They were known to Aristotle and St. Thomas and were discussed by Cardinal Cajetan, one of the great commentators on St. Thomas' work. In our own day, these so-called intermediate sciences have been ably discussed by Jacques Maritain, a real pioneer in Thomistic discussions of modern science.[15]

For whatever its worth, there is one principal difference between intermediate science in the framework of Aristotle and Aquinas and the mathematical physics of modern times. In a tradition that begins with the Greeks and descends at least as far as Copernicus, intermediate science was believed to provide an exact fit between mathematical description and physical fact; it was thought, for example, that heavenly bodies moved in perfect circles and that such motions could be exactly described in our mathematical formulae. Modern scientists, on the other hand, believe that physical events only approximate our mathematical equations. It is true that many arguments in mathematical physics are only dialectical. One reason is that the physical facts are not sufficiently known as in the case of the relative motions of the earth and the sun; another reason is that our mathematics, in exploring physical problems, is often dialectical. But it would be a mistake to conclude that mathematical physics is nothing but dialectical knowledge. In the case of the circular wound, an approximate circle would have a greater area than an approximate square of the same perimeter, and the approximate circle of the earth's shadow on the moon could give us certain knowledge that the earth was not, for example, oblong. A conclusion can still be certain even when holding within limits.

By mathematical middle terms, it can be demonstrated that an approximately spherical body of a given substance, say wood, will roll along a fairly smooth, rectilinear surface more readily than a body of the same material and same weight which is more cubical in shape. By measuring the angle of the north star about the horizon at various latitudes, it could be demonstrated, as the Greeks proposed, that the earth is round, and the middle or causal term would be a mathematical one.[16] By the figure and hence mathematical principle of various wing designs, aeronautical engineers can demonstrate why one kind of airplane flies with these characteristics and another with those. Another example of mathematical physics is the principle of the lever. In short, it is possible, in principle, for mathematical physics to attain certain knowledge; but frequently, as in the case of Newton's first law, there is a

dialectical or conceptual scheme that remains to qualify our conclusions in mathematical physics and allied subjects and to make them at best merely dialectical inductions.

As a liberal art, with an object affiliated with what was formerly known as the quadrivium, mathematical physics, at least in part, can and should be studied, even in high school, before the strictly physical or natural science we have been trying to elaborate. It presupposes, at its beginning, only common and dialectical knowledge concerning nature. But when it comes to putting together a synthetic natural science, general considerations of nature should take place first, and mathematical physics, because of its end, should come, pedagogically, at a later moment. The point here is that mathematical disciplines, even though as liberal arts they are learned prior to strictly natural science, cannot claim, as physical sciences, to present the full picture of nature but must be considered as supplying details within a synthetic natural science whose beginnings are the general science of nature. When the mind puts together its total view of nature as physical, our general science should be articulated first and mathematical physics, changing from the context of a liberal art into a natural science, should be fitted in later. This is the sense of the logical (pedagogical) priority of our general and strictly physical science over a physics that is mathematical.

This is by no means the place to decide what is certain and what is uncertain in modern mathematical physics. Of much greater importance is the likeness in aim and in matter between mathematical physics and the study of mobile being in general, and the difference in aim and in matter between pure mathematics and the science of nature.

IV. THE SCIENCE OF NATURE AND MATTER/FORM

a. *The Question*

From different points of view, nature, the intrinsic principle of motion in things, is both matter and form. Does the science of nature study mobile being in terms of one or other of these two principles or must it take both of them into account? Moreover, if chemistry and biology, and for special reasons mathematical physics, are a continuation of our science of nature, how does science in the modern sense relate to matter and form?

At first glance, it would look as though the science of nature in our meaning of the term is interested only in form because form is the

principle in each thing which makes it to be the original kind of mobile being that it is — dog, copper, rosebush, water. On the other hand, modern investigators of nature, especially in physics and chemistry, seem to get along very well apparently without taking form into account at all. Matter alone, in one or other of its contemporary meanings, seems of interest to the present-day student of nature. Even though the modern investigator, when pressed, may be unable to define matter, it remains true that the one item of earlier tradition which modern research seems to find expendable in the notion of form.[17]

Proof that form is real and not merely a mental figment or a grammatical convenience has already been accomplished in previous chapters. Subject, form, and privation are naturally required for motion, and primary matter, its substantial form, and the corresponding privation are the first principles of nature. Our question now is no longer the reality of form but the relevance of form and its corresponding matter to a truly scientific knowledge of nature, a knowledge that is certain and causal. That both form and matter have to be considered in such a science will be shown first, and afterward it will be argued that both of these principles can be studied even by modern physics and modern chemistry.

b. *The Science of Nature Must Consider Matter*

Medicine can show us that scientific knowledge of the material world must take matter and form into account. A doctor is interested in the health of his patient which, as a physical quality, is an accidental form of the body. But to study health in a successfully scientific way, discovering its causes and reasons and hence the means of controlling disease, the doctor is obliged to study matter. When illness occurs, he tries to dispose the matter in such a way that the form of health will come about. This disposition of matter may be achieved by rest, diet, chemical therapy, or surgery — to mention the more prominent techniques for manipulating matter to bring about form. But the point is that the doctor must take account of matter as well as of form.[18]

Moreover, form, as previously explained, is the end of matter. And just as a master builder like a shipmaker has to take matter into account if his product is to serve its final purpose and hence possess its final form, so whenever and wherever there is form determining matter, the matter must be taken into account if the form itself is to be properly understood. Natural science must therefore consider matter.[19]

Moreover, wherever there is an end, the science that considers the

end also considers the means. Thus, the same science which considers the earthly end of man, e.g., the temporal common good as studied in ethics, also considers the means to reach this end, e.g., the various institutions of society. All such means tend to the common good; precisely from such a tendency they get their character as political institutions and as politically meaningful in our own study of them. In similar way, matter is for form because form is the end of matter; to the science which considers form belongs also the study of matter as disposed in a proper way to the form that is its end.[20]

c. The Science of *Nature Must Consider Form*

If matter belongs in a science of mobile being, even more so does form.[21] Form is the principle which makes each kind of material thing an original type. It determines matter so that this species of thing rather than that will result. If our science wants to get at the principles which make things to be as they are and not something else, form must surely be taken into consideration. Unorganized and indeterminate in itself, matter receives its organization and determination from form. When we know the form of anything we know the very principle of its organization.[22] Without form, things would be utterly disorganized and unintelligible; without taking form into account, our quest for understanding our world would stop short of a principle necessary for that organization of our knowledge which we call science.

V. MODERN SCIENCE AND MATTER/FORM

a. *Presuppositions in Our Present Problem*

In the order of becoming, form is the end of matter.[23] The end of matter, once becoming has ceased, is its form. In an embryo, for instance, the form or soul that will eventually be present is the end of the matter which is undergoing development and, through the development, is being disposed to its ultimate form; and when the process has ceased, the end is the form. The end of becoming is always the form in being.[24] Any natural process can be seen by observation to involve a greater or less complexity; it at least involves stages.[25] What was the end of the matter while the process was going on is the form of the matter when the process has ceased. All of this follows upon our previous characterization of form as the end of matter. It is being recalled here

because it enables us to make a transition to our second question in the present context: How do matter and form relate to researches as specialized and as quantitative as, for instance, atomic physics, chemistry, and anatomy?

In treating matter and form the general science of mobile being can do no more than establish their existence on the basis of experiential evidence; but neither the induction to a subject and two contraries as the principles of accidental motion nor the understanding of primary matter, substantial form, and privation as the first principles of nature provides knowledge concerning types of form — concerning the difference between the form of horse and the form of copper, the form of sycamore tree and the form of water. The very knowledge that such forms exist, let alone knowledge of their kind, requires experience beyond that which tells us that all motion involves a subject and, in a wide sense of the word, two contraries.

After general experience has taken us as far as it can into knowledge both of the existence of things and of their natures, it is necessary to continue such knowledge by that refined and artificial experience which we call experiment. The science of nature is far from a deductive system.[26] In explaining what experience and experiment present to us, viz., that there are such things as horses, hydrogen, sycamores, and water, and in explaining what experience and experiment reveal to us concerning the likenesses and differences of such mobile beings, matter and form are useful principles. They are principles for explaining mobile beings but they do not permit us to deduce the existence of the material things we explain or to deduce anything about the natures of these material things. They are not principles of discovery,[27] but principles of explanation or judgment concerning things we discover through experience.

The science of nature is thus through and through an empirical enterprise. David Hume was right in claiming that we could never deduce from the knowledge of the essence of bread that it has the property of nourishing man; nor from knowing the essence of copper could anything be inferred concerning its color or specific gravity or valence or conductivity. The properties of material things can be known only from and through experience, and were it not for experience, the mind would never know that there was copper or bread to begin with, let alone anything about the natures of such realities. The science of nature, whether at its general or more particular levels, can never make a single claim to truth without experiential support.

b. *Effects of Form in Matter*

From the fact that horses, copper, sycamores, and water are capable of coming-to-be and passing-away, we know that they involve in their very essence a subject and a form. But the kind of form which each kind of thing embodies requires an inductive survey of the characteristics displayed by the mobile beings under investigation. The horse has a shape and size that are fairly determinate and enable us to differentiate this kind of animal from a dog and from a cow. We know that water is a liquid from taste, sight, and touch. A sycamore has a distinctive bark and leaf. All such characteristics, observed through common experience and properly analyzed at this level, get us started along the road to an understanding of what the kinds of mobile being really are. When found and sufficiently verified, the characteristics peculiar to each kind of mobile being reveal to us something of the forms of such material things — as an effect reveals to us something about its cause. All our knowledge concerning kinds of form is obtained in some way through the effects produced by the form in question.

But knowledge of natural form through effects peculiar to the form will usually be more or less imprecise so long as such knowledge remains at the level of general experience; knowledge obtained at this level, however sure, is very imperfect and requires to be complemented by experiment, refined by measurement, and supported by dialectical construction that we ordinarily term theory or hypothesis. The techniques of what we have come to call the scientific method enlighten the mind concerning the precise weights, finer structures, electrical charges, radioactive half-lives, and other tendencies peculiar to the various kinds of mobile being. In this fashion, science in the modern sense of the term discloses to us more about forms we already know and even aids us in the discovery of new forms we would not otherwise know to exist.

When iron combines with oxygen to form rust, the chemist talks about the union of atoms and the physicist about the interplay of subatomic particles. All of this may be valid in its place, but it presupposes an earlier and more reliable report which affirms that old things have substantially changed into new ones. We are working, in our general science, at a level before knowledge is distinct enough to know even that iron and oxygen exist, let alone the details of their combination. Our general knowledge is more certain than knowledge provided by chemistry and physics and is presupposed by them.

It bears repetition that the mathematical and experimental techniques usual in modern investigations of matter do not directly grasp either the subject or the form in any motion; and so it would be useless to expect microscopes or other instruments to lay hold of such principles. Experiment and measurement can detect only a thing that is (principium quod) and not a principle by which (principium quo) a thing is.[28] That change involves a subject and a form as its essential principles can be established only by analyzing the coming-to-be and passing-away of things; without a concept of subject and form, it would be impossible even to represent motion in our intellects. But once we establish by non-mathematical and pre-experimental analysis that mobile being has a subject and a form, measurement and experiment enable us to know more about the form itself as revealed by its effects.

c. *Properties as Signs of Form*

From logic, it can be argued that properties at least, not to mention other characteristics, reveal something about the forms involved. Effects can always reveal to us something about their causes, and this is true in a special way of properties as the effects of form. For instance, it belongs to uranium to be a very heavy element; but the modern physicist does not leave us with such a vague knowledge of uranium's weight. Having discovered uranium in the first place by that specialized experience we call experiment, the modern physicist goes on to tell us in quite exact terms the weights of the various sorts (isotopes) of uranium, the charge on the uranium nucleus or in the orbits of the atom, and other peculiarities of the element. The modern physicist does not tell us that uranium involves a subject and a form; this we know when we discover that uranium is a mobile being and hence, like all things capable of coming-to-be and passing-away, constituted of a primary subject and a substantial form.

So important in present-day circumstances is the relation between matter, form, and measurement that it ought to be approached from as many angles as possible in order to be properly understood. It is easy enough to announce an opinion on the relation between what we have called the general science of nature on the one hand and science in the modern sense of the term on the other. Our position in this regard, as dictated by the logic of demonstration, has insisted less on the differences between the general science of nature and science in the modern sense of the term than on their likenesses in object and in

logical direction. Our present discussion will, it is hoped, display in action how science in the modern sense of the term continues what we have called the general science of nature.

In regard to weighing things, for instance, no knowledge of what weight is could be obtained by measurement alone. But once we have come to know what weight is by means of our effort in lifting things, then measurement can tell us a great deal more about what we already know. Weight itself, as a tendency — for ordinary purposes the tendency of a thing toward the earth — is qualitative in character. Hence, weight cannot be discovered by metrical, quantitative methods. Yet, as a qualitative form, weight determines the quantitative aspect of bodies as material, so much so that we can use a calibrated scale to differentiate one kind of body from another. Because the quality determines the quantitative in the phenomenon of weight, we speak of things as being more or less — a quantitative language — heavy or light. However, weight cannot be purely quantitative; the whole of mathematics, the science of quantity, could never convey what is meant by weight to one who did not know it in a non-quantitative manner.

d. *Quantified Effects of Quality*

Quality is related to the quantified as form is related to matter.[29] In the fourfold hierarchy of structure as earlier explained, quality modifies or determines the quantified. It invests the quantified with, for instance, shape or figure, and thus from the very figures of things, especially in the living world, we can often identify their kind.[30] From a mere silhouette, it is usually possible to recognize many animals — horses, giraffes, elephants, etc. There are books with simple black and white drawings for identifying wild flowers and birds in our region of the world, and since the drawings omit color, the books work on the principle that the mere outlines of living things can identify them. Such outlines are signs. Figure or pattern is a clue to the differentiation of crystals and hence yields knowledge of the substantial form even in the mineral world. Even though he works with conceptual schemes and thus makes dialectical constructions, the physicist insists that there is a pattern for the arrangement of orbital electrons in all atoms and that each kind of atom has its own peculiar pattern.[31] All such cases manifest the effects of quality in the quantified, or in a more general sense, the effects of form in matter.

The mind never comes into direct contact with quality or quantity.

These are not existing things (principia quod) . . . but principles by which (principia quo). ... In mathematical physics and even in biology, there are reports of the way in which qualities like weight, charge, figure, etc., have affected previously quantified matter in our hierarchy of structure, and when the qualified product of this quantified matter happens to be proper to the mobile being in question, it reveals to us the form of the mobile being.

Optics and acoustics are two fields rich in illustrations of how the quality, as a form, is related to its matter, quantified substance. Color can be varied by changing the quantitative features of its source so that a different wave length is emitted. By changes in the more material principle of a thing, i.e., the quantified, we change the formal. Just as in the case of a living thing, like man, the material side may be so affected by disease that the form is no longer able to animate the matter and death occurs, so other forms can be driven out of or brought into existence by the way in which the material principle is disposed. In this way, changes in color and in sound can be achieved by controlling the quantified matter involved. Color, as it exists in its source, that is, the colored object which is the object of our vision, is the effect produced by quality in quantified matter.

The quantified alone can never tell us that there are qualities or what kind of qualities there may be in matter. Even though he knows in great detail the mathematics of spectroscopy, a man born blind will remain forever ignorant of what color is. A person, hearing the expression ten pounds and able to perform many wonderful mathematical operations with this quantity, would remain ignorant of weight unless he lifted something or had some other similar experience of a qualitative world. Even our silhouette of cats and elephants in a book for identifying animals and even the geometry of a crystal lattice could never of themselves enlighten the mind concerning physical things. That is, they could never give us knowledge of the two principles of quality and the quantified and how they are related to each other. Such knowledge must be obtained by the experience of change.

When we look at things or know them in any other way by means of our senses, it is not quality that we apprehend. We do not see redness or taste sweetness; nor do we see or feel figure. We see the red — for the object of our sense of sight is not color but the colored; we taste the sweet and see or feel figured matter.[32] But once we know that the red, the sweet, and the figured exist, there is probably no other knowledge we can gain of them except by resort to quantitative details.

Thus, modern investigators of nature, through experiment and measurement, enrich our knowledge of physical form by studying its effects. Sometimes this form may be known in a general way by common experience, so that the quantitative approach of science in the modern sense can do no more than enlarge a knowledge already present to the mind in a confused and general way. Frequently, however, modern quantitative researches into nature reveal to us in an indirect way and by means of effects the very existence of forms that general experience would never suspect.

e. *Structure, Mass, and Energy as Effects of Form*

Structure in things, from man to hypothetically known atoms, is another effect produced by form in quantified matter. In the nucleus of helium, for instance, there are two protons and ordinarily two neutrons, and in the orbital region of the atom, there are two electrons. Such a structural arrangement is ultimately the result of the form of helium operating on quantified matter; and from knowledge of such structures comes knowledge of the form which is their cause. In a kindred way, the masses and energies characteristic of each kind of element are effects of the form of the element in question and reflect the peculiar character of that form; to know the masses or energies characteristic of this or that element is to know at least something concerning the form of that element.

Structure, mass, energy, and other such realities specific to any kind of thing are not matter, and they are not form. They are, in each case, effects produced by the formal principle in the material one. lire same verdict holds in biology where the structures peculiar to various organisms throw light upon the forms or souls of those organisms.

In our unified science of nature, all of the successes of chemistry, physics, and biology thus enrich our knowledge of form, accidental, substantial, or both. Let it be repeated that much of this success is tentative; the knowledge involved is often hypothetical and dialectical. But it is better to have tentative knowledge of form, the principal component in nature and the component which the rest of nature intends,[33] than it is to have a lot of certain knowledge concerning lesser things.[34]

The biologist, in pursuit of anatomy, is also studying how form affects or modifies or determines a material substratum. He is studying the effects of form. Tire form or soul of any animal or plant, say a German police dog, determines the quantified matter in such a way

that there results the system of organs and parts of organs that investigation discloses. The soul or form of an oak tree produces in matter its own proper effects that can be experienced and subjected to experiment.

By way of drawing this section to a conclusion, it may be pointed out that the effects produced by form in matter reveal much more about the form than the effects of an efficient cause reveal the efficient cause in its nature. But this problem anticipates the study of the efficient cause in the next chapter.

V!. THE SIGNIFICANCE OF GENERAL SCIENCE FOR SPECIAL SCIENCES

a. *How Special Sciences Become Sciences*

The apparently naïve and often unanalyzed knowledge obtained from general experience, that there are three principles of motion in our world, thus turns out to be of great significance. Such knowledge provides a context within which the data unearthed by science in its modern sense can be made much more meaningful than they would otherwise be. If, as was argued, everything in nature is derived from our three first principles, all studies of nature must reflect these principles; and our present discussion has shown how physics, chemistry, and biology shed light on form. Unless they are set within a perspective of first principles, it is difficult to see how the modern sciences can justify themselves as anything more than preparations for practical arts like engineering, medicine, and agriculture.

Against the background of first principles, special investigations of nature assume the character of physical science in the Aristotelian sense. They participate in this science and are reductive to it as the imperfect is reductive to the perfect. Even when dialectical, these special investigations are on the road to science in the sense we have given it from our logic of demonstration. Thus our general science and science in the modern sense go together in a logical way to form one basic discipline. Modern physics, chemistry, and biology afford more detailed, precise, and distinct notions of what in a vague and confused way we know already, and that is why, when put in the light of the general science of nature which they merely continue, physics, chemistry, and biology can be called special sciences.[35] Apart from this light of first principles, they are not truly explanatory in the physical sense; they leave unanalyzed the real physical causes and reasons why our world is as it is. The

modern sciences offer our best hope of knowing what is proper and primary to each species of physical thing.

b. *How Special Sciences Know God*

The mind has a natural tendency to know form because it has a natural tendency to seek the reasons for the organization of things. Form is a principle of organization; it is a principle of knowability. For St. Thomas, the whole aim of the science of nature is to get at knowledge of the form of man.[36] This form is the end of the physical universe, as a later discussion will bring out; all other physical knowledge throws light upon it. Moreover, if form, as Aristotle remarked, is the divine element in things,[37] a reflection of God who is Pure Act with no potency, then to know form leads to a knowledge of God. Such knowledge of God through form can take place in a scientific way only after we know that God exists (Chapter XIX). Tire more we can learn of form through modern science the more we will know about God.

Knowing from the experience of change that there is matter and form in the world, we are able to put the data of modern science into a perspective as the effects of form; and knowledge of form in creatures allows us to gain an analogous notion of God, the cause of form in creatures.

VII. SUMMARY

In our present chapter, it was shown that in material reality substance receives its accidents in a definite order. First there is quantity, then quality, and finally the motions of matter. Since prior things do not require posterior things in order to be understood, quantified substance can be conceived without qualities and motions, and hence there can be a science of mathematics independent of the science of nature. The science of nature takes account of the fourfold hierarchy of structure but mathematics studies only the first two members, as in quantified substance.

Unlike pure mathematics, mathematical physics deals with mobile being even though it uses mathematical principles. Though formally mathematical, such physics, by reason of its end, belongs to the same body of knowledge as our science of nature and simply furnishes a more particular view of mobile being than our general science attains. For the form of anything mobile affects matter in such a fashion that the properties and structures studied by our mathematical physics appear

in that matter; such effects of form in matter enable us to know more about the form itself, and hence science in the modern sense of the term enriches our knowledge of form.

It is true that in their present historical setting, physics, chemistry, and biology have come to be regarded as branches of knowledge different in kind from our general science of nature. They are each taught in distinct departments of our educational system, and if only for this reason they seem to be not only independent of our general science of nature but even independent of each other. But the way in which modern physics, chemistry, and biology — together with their divisions and subdivisions — have developed in their historical setting is not necessarily the way they should be in their internal logical structure and in their logical relationships to one another. Unless we relate their knowledges of the effects of form to the form itself, these areas of science in the modern sense will not be able to pursue their knowledges to their ultimate physical sources or first principles. Such a pursuit may not add any new facts to modern science or modify its theories; but it would give modern investigations of nature a new significance within the total economy of human thought.

REVIEW QUESTIONS

1. Why did Aristotle introduce a study of the relationship between physical and mathematical knowledge right after his definition of nature?
2. What are some evidences that might lead to a confusion of mathematical and physical science?
3. State the order in which "accidents" are related to materia] substance.
4. How does this interrelationship enable us to consider mathematics as independent of physics?
5. Show how mathematics, as viewed by St. Thomas and by Aristotle, is about the real.
6. Explain how physical science studies quantified being.
7. Explain the difference between mathematics and mathematical physics.
8. What is the likeness between our general science and mathematical physics?
9. Why is mathematical physics called an intermediate science?
10. Why is it more physical than mathematical and how is it reductive to the science of nature?
11. Explain any differences between the ancient intermediate sciences, such as astronomy, and modern physics with its approximate character.
12. Prove that the science of nature must consider matter.
13. Prove that it must also consider form.
14. Show how the science of nature is everywhere dependent on experience.

15. In what way do we get our knowledge of form?
16. How does science in the modern sense of the term increase this knowledge?
17. With what do measurement and experiment deal in the context of matter and form? Explain.
18. Explain how a characteristic of a material thing, such as weight, can enlighten us concerning form.
19. How does the quantified reveal the qualities of things to us?
20. What is the meaning of structure, mass, energy, and other such entities, in the light of matter and form?
21. How do sciences in the modern sense become "scientific" in Aristotle's sense?
22. What is the relationship of modern science to a knowledge of God?

PROBLEMS

In the light of the discussions of the present chapter, comment on the following passages:

I

"Some have thought that the species of a natural thing is a form only, and that matter is not part of the species. If that were so, matter would not enter into the definition of natural things. Therefore we must disagree and say that matter is twofold, common and signate, or individual: common, such as flesh and bone; individual, such as this flesh and these bones. The intellect therefore abstracts the species of a natural thing from the individual sensible matter, but not from the common sensible matter. For example, it abstracts the species of man from this flesh and these bones, which do not belong to the species as such, but to the individual, and need not be considered in the species. But the species of man cannot be abstracted by the intellect from flesh and bones.

"Mathematical species, however, can be abstracted by the intellect not only from individual sensible matter, but also from common sensible matter. But they cannot be abstracted from common intelligible matter, but only from individual intelligible matter. For sensible matter is corporeal matter as subject to sensible qualities, such as being cold or hot, hard or soft, and the like; while intelligible matter is substance as subject to quantity. Now it is manifest that quantity is in substance before sensible qualities are. Hence quantities, such as number, dimension, and figures, which are the terminations of quantity, can be considered apart from sensible qualities, and this is to abstract them from sensible matter. But they cannot be considered without understanding the substance which is subject to the quantity, for that would be to abstract them from common intelligible matter. Yet they can be considered apart from this or that substance, and this is to abstract them from individual intelligible matter.

"But some things can be abstracted even from common intelligible matter, such as being, unity, potency, act and the like, all of which can

exist without matter, as can be verified in the case of immaterial substances. And because Plato failed to consider the twofold kind of abstraction, as above explained, he held that all those things which we have stated to be abstracted by the intellect, are abstract in reality."

St. Thomas Aquinas, *Summa Theologiae*[38]

II

"This science, which has been so vastly successful these last three centuries, may be said to consist of a progressive mathematization of the sensible and its success, as you know, has been especially remarkable in Physics. The type to which it belongs was not unknown to the ancients but they had discerned it only in restricted and particular fields such as astronomy, harmony and geometric optics. They had pointed out that these were intermediary sciences, *scientia media* as they so aptly termed them. According to Aristotelian and Thomistic principles, such knowledge must be considered as formally mathematical because its rule of interpretation, its rule of analysis and deduction, is mathematical.

"But on the other hand, although this knowledge is formally mathematical, it is materially physical because what it assembles and interprets by the help of mathematical intelligibility (particularly, as soon as this tool was invented, by the help of a system of differential equations) is physical reality, physical data. Such sciences may hence be said to be formally mathematical and materially physical. They are, as it were, astride the first and second orders of abstractive visualization; materially they belong to the first order; formally — and this is what is particularly important in a science: its rule of explanation and interpretation — formally they belong to the second order of abstraction, to the mathematical order.

"One further remark about these sciences. In his Commentary on the second book of Aristotle's *Physics,* St. Thomas draws attention to the fact that, while these sciences are formally mathematical they are nevertheless more physical because, says he, their term, — the terminus in which judgment is completed and verified, — is sensible nature.

"Herewith an historical parenthesis. As a matter of fact what I just mentioned was not expressly said by Aristotle; St. Thomas said it, basing himself on a text of Aristotle which, to our greater advantage, he misinterpreted. In Chapter 2, 194a, 7, lib. II of the *Physics,* Aristotle is speaking of mathematical knowledge and he speaks of the branches of mathematics which are more physical than others, more concerned with physical things; these he calls rd ***^vacKwrepa*** *t ôîv* ***p-adrjixaroiv,*** which modern translators have with good reason translated as 'the more physical of the branches of mathematics.' St. Thomas, on the contrary, in his 3rd lesson on the second book of the *Physics,* understands this expression to mean not the more physical branches of mathematics but sciences that are more physical than mathematical. . . . That enables him to state a very important point of doctrine, namely that the while they remain formally mathematical, these

sciences are more physical: because the consideration of these sciences is terminated in natural matter, although it proceeds through mathematical principles. Their weight as science draws them toward physical existence although their rule of interpretation and deduction is mathematical. From this you can see immediately the kind of internal disparity there will be in this scientific realm: The scientist will be drawn at the same time towards the physical real with its proper mysteries and existentiality, and towards mathematical intellection and explanations. At certain times one or the other tendency will appear to predominate; actually the scientist is on both these planes simultaneously; he is the more on the physical plane as to the term of knowledge, the while he is on the mathematical plane formally, as to the rule of interpretation and explanation."

Jacques Maritain, Philosophy of Nature[39]

NOTES TO CHAPTER VIII

1. Cf. Com. on the Phys., Bk. I, les. 1, 1-
2. *The Mysterious Universe* (New York, 1937), p. 167.
3. Com. on the Trin., q. 5, a. 1.
4. Phys., Bk. II, ch. 2, 193b, 32-35; Com. on the *Phys.,* Bk. II, les. 3, 8; Sum. cont. Gent., Bk. II, ch. 14.
5. Com. on the Trin., q. 5, a. 3; Com. on the Phys., Bk. II, les. 3, 5; Com. on On the Soul, Bk. II, les. 8; Summa *Theol.,* I, q. 85, a. I and reply 2; Sum. cont. Gent., Bk. IV, ch. 63.
6. John of St. Thomas, Curs. Phil., Log. II. P., O. XVI, a. 1, ed. Reiser (Turin, 1930), I, 540 ff.
7. Com. on the *Phys.,* Bk. II, les. 3, 5, ed. Angeli-Pirotta, translation mine.
8. Com. on the Trin., q. 5, a. 3; Phys., Bk. II, ch. 2, 194b, 9-11.
9. Com. on *the Phys.,* Bk. II, les. 3, ed. Angeli-Pirotta, n. 333, translation mine.
10. Com. on the Met., Bk. XI, les. 10, n. 2339; Sum. cont. Gent., Bk. I, ch. 82.
11. For the meaning of subalternation, cf. B. Mullahy, "Subalternation and Mathematical Physics," Laval *Théologique et Philosophique,* II (1946), 89-107.
12. Com. on the Phys., Bk. III, les. 3, 8.
13. Such more distinct and detailed knowledge of material species is necessary for the perfection of our science of nature; cf. Com. on the Meteor., Bk. I, les. 1; Com. on the Met., Bk. VIII, les. 4, n. 1738.
14. Com. on the Trin., q. 5, a. 3, replies 5 and 6; Com. on On the Heavens, Bk. I, les. 4; Surama Theol., II–II, q. 9, a. 2, reply 2.
15. J. Maritain also lays great stress on the intermediate sciences. For a Maritain bibliography on the question cf. *The Division and Methods* of the *Sciences,* trans. A. Maurer (Toronto, 1953), p. 33, n. 19; for a different discussion of this problem by another Aristotelian, cf. B. Ashley, "Aristotle's Sluggish Earth: the Problematics of the *De* Caelo," The New Scholasticism, XXII (1958), 1-34.
16. From considerations of astronomy the Greeks even proved the approximate circumference of the earth before Magellan's voyage gave the *physical* proof that the earth is round.
17. By the seventeenth century "form" had already come to be considered an "occult quality."
18. Phys., Bk. II, ch. 2, 194a, 21-25.
19. *Ibid.,* Bk. II, ch. 2, 194a, 34-194b, 8.
20. Ibid., Bk. II, ch. 2, 194a, 26-33.
21. Com. on the Phys., Bk. II, les. 4, n. 8.
22. Com. on the Eth., Bk. IX, II, n. 1904.
23. Com. on *the Phys.,* Bk. I, les. 15, n. 10.
24. Ibid., Bk. II, les. 11, 2.
25. On the *Power* of God, q. 4, aa. 1 and 2.

26. *Com. on On the Senses,* les. I.
27. For the distinction between discovery and proof, cf. Exposition of *the Post.* Anal., prologue.
28. That matter and form are principia quo, cf. Com. on *the Met.,* Bk. VII, les. 7, n. 1419; *On Truth,* q. 22, a. 3 and q. 24, a. 1.
29. Because quantity is a subject by which other accidents inhere and, as subject, is matter. Cf. Com. on On *the Soul,* Bk. II, les. 8.
30. Com. on the Phys., Bk. VII, les. 5, n. 1848.
31. Some authors are reviving the word form to designate this structural pattern; cf. L. Whyte, *Accent* on Form (New York, 1954), ch. II; E. Schroedinger, Science and *Humanism* (New York, 1952), p. 18 ff.
32. Cf., for example, Com. on On *the Soul,* Bk. II, les. 14, n. 403.
33. Cf. Chapter XII.
34. Aristotle, On the Parts of Animals, ch. 5, 644b, 33-645a, 1.
35. One universal science thus has particular sciences in it; cf. On the *Power of Cod,* q. 4, a. 2, reply 19.
36. Com. on *the Phys.,* Bk. II, les. 4, 9, 10.
37. *Phys.,* Bk. I, ch. 9, 192a, 17-18; cf. also Com. on the Phys., Bk. I, les. 15, 7; Sum. cont. Gent., Bk. I, ch. 70; Bk. III, ch. 97.
38. I, q. 85, a. 1, reply 2. Unless otherwise noted, direct citations from the *Summa* Theol. are taken from the translation by A. C. Pegis, The Basic Writings *of St. Thomas* Aquinas, 2 vols. (New York, 1945) and are reprinted with the permission of Random House, Inc.
39. Translated by I. Byrne (New York, 1951), pp. 38-39. I have taken the liberty of translating into English two more or less long phrases that M. Maritain put into Latin. Reprinted with permission of Philosophical Library.

CHAPTER IX

CAUSES IN THE SCIENCE OF NATURE

I. MATTER AND FORM AS CAUSES

a. Causes as *Middle Terms*

After showing that there are hrst principles in the material world and hence that a science of natural things is possible (Chapters IV-VI), our logic took us to a more precise determination of what we mean by the subject of our science (Chapter VII), what we mean by natural things or things having a nature. It is important both to distinguish this subject from that of mathematics and to relate it to that of mathematical physics (Chapter VIII). With the knowledge that a science of nature is possible and with a notion of the subject of that science, it will be profitable now to look at the middle terms by which demonstrations are made within our science.[1]

Now a middle term represents the cause or reason why an attribute in the conclusion of a syllogism is predicated of a subject.[2] Thus our present problem asks about the meaning of cause in our science of nature. What is the cause or causes by which our natural science proves its conclusions?

As in our preceding inquiries, the answer to our present question can be supplied only by an induction prepared by an appropriate dialectical scheme; again, as in our earlier investigations, we can only give nominal definitions of the various kinds of causes since there is no reality in our world more basic than its causes in terms of which our definitions of these causes could be cast. Our following definitions are not real, only nominal.

A cause is that on which something else depends for its being or becoming,[3] and in order to have a sure and scientific grasp of physical things, the mind must know the causes upon which those things depend. Since causality as such is independent of matter and motion and applies to all things, material or immaterial, the analysis of the nature of causality is proper to metaphysics or natural theology. With the aid of an induction preceded by the usual dialectic, the science of nature can do no more than discover that there are various types of causes in the physical world, leaving to metaphysics or natural theology the task of explaining in a truly scientific way what it is to be a cause. Frequently it is important to distinguish between a cause and a principle; but frequently too, the two terms are used interchangeably.[4]

b. *Metier as a Cause*

In this light, matter and form which were previously shown to be principles can also be seen to be causes. Matter, primary or secondary, is the intrinsic principle from which a thing comes to be. This definition can be presumed as already established and need here only be recalled. As intrinsic, matter or material cause is distinguished from privation, which is extrinsic (since it does not enter into the effect) and accidental; as a principle from which, matter is distinguished from form, which is that to which a motion tends. Bronze is the matter of a statue; clay of the object that is shaped now as a sphere and now as a cube. Both the bronze and the clay are essential to the effects which they form because without them the result would not be what it is; they are intrinsic to the effect. Moreover, they are each a matrix from which a motion occurs and not the term to which the motion tends. From such a dialectical construction drawn from human art, it can be argued that there is a material cause in all natural change — primary matter in the case of substantial change and secondary matter in the case of accidental change; evidence to support this conclusion is undeniable.

c. Form as *a Cause*

Form, to recall another previous definition, is the end of matter. It intrinsically determines and intrinsically organizes matter. As substantial form united to primary matter, form or the formal cause brings about a species or essence.[5]

Now it is species in the material world that natural science really is after, what is copper and why it is so; what is a dog and what are its causes; what it is that makes hydrogen to be hydrogen and silver to be silver. General knowledge that remains above the species of things is always imperfect in content; knowledge that goes below species to the level of individuals is always of the non-necessary. It is in knowing the species or essences of things that human knowledge of nature reaches its perfection.[6]

Species is compared to the individual, i.e., copper is related to this copper and dog to this dog, as form to matter; and for this reason, form is frequently taken as meaning the whole species or essence, that is, the composite of matter and form.[7] Form in this sense means that by which a thing is what it is, dog, copper, man,[8] etc. This use of the term form to mean the whole species is a legitimate and valuable one. It is an extremely useful definition in many ways even in our own science of nature. But such a meaning of the term form will not be employed in this introductory book.

Form or formal cause in these pages means the determinant of matter. It is the organizing or actualizing principle of matter. It is the type of form that in union with matter constitutes the species or essence which is form in a second meaning of the term.[9]

Thus in outer appearance and inner organic structure, wrens have in common certain material structures; copper likewise owns a typical structure that chemistry and physics reveal to us. Each species of thing has its own peculiar specific form and a properly specific matter as determined by that form and as explained in our past chapter. This specific form, as part of a species or essence, is the form or formal cause that is of interest in this book; form in the sense not of a part but of a whole species must be discussed in a more advanced context than the present one.

d. *Intrinsic Causality as Causality*

Matter and form are causes. Mobile being depends on matter and form in order to be and to come to be. Matter and form have a positive influence on the composite which is their joint effect. Tire material and formal cause are each distinct from the whole which they constitute since neither is the same as that whole. That is why, even though intrinsic to the effect, they are distinct enough from the total effect to

be called its causes.[10] Copper is neither matter nor form but a composite of the two, the effect of the two. Matter and form are in the effect but only as part of it. They may thus be called intrinsic causes: intrinsic because they are in the effect and causes because the effect depends on them.

II. THE EVOLUTION OF FORM FROM MATTER

a. *The "Union" of Form and Matter*

It is now an appropriate moment to tighten up our terminology concerning the combination of matter and form. Reference has been made to the composition of these two principles or to their union; but this should not create a picture of uniting one thing to another as one puts together two pre-existing bricks or spreads the butter on the bread. Form is not imposed on matter in natural change but rather is derived from matter's potencies. This derivation of form from the capabilities of matter may be variously described as eduction, emergence, and even evolution.[11]

Tire form in natural change is not a pre-existing seal or stamp that is foisted upon matter from without. In the case of molding clay, let us suppose the clay to be kneaded in such a fashion that after having the shape first of a sphere it later has the form of a cube. Initially, the clay contained in potency the cubical shape, and when that cubical shape became actual, it was not so much impressed on the clay from without as it was worked out of the clay from within. The cubical shape was in the clay. It was there in potency. After the motion, it is there in act.

There is a description of Platonic origin concerning sculpturing where the artist is presented not as putting something into the marble but as getting something out of it. He peels away the marble so that what is left after the process is the statue that was intended. Tire sculptor trims away the "excess" marble surrounding the figure so that the figure itself is liberated.[12] This Platonic metaphor is too strong to be more than a rhetorical device to put us on the trail of what is involved in the "union" of matter and form. It is, however, probably misleading to say "union" or "composition." As our example of the clay showed, there is no union or composition of two pre-existing things but rather a "working out" from the matter of what was there in potency. There is less an imposition or impression from without than there is an evolution from within.

b. *The Disposition of the Potential*

The various workers who produced the brilliant lights along Broadway, the men who make a television set, or the space engineers who produce a baby moon do not impose any pre-existing physical mold or seal on their materials; they arrange the materials so that the final effect they intend will come forth from the materials. Even arts that add to nature, thus producing that which nature does not have the efficient causality to make,[13] dispose the potencies of their materials to produce the intended effects.

In a manner quite similar, natural forms are contained within the potencies of the matter involved,[14] and as change goes on there is an emergence, evolution, or eduction of the form. The matter in the acorn is a potency for the oak tree that originates from it. The form of ashes or of water was in some way potential in the matter of wood and in that of hydrogen and oxygen, and when such matter is properly disposed, the forms emerge into act.

III. THE CAUSALITY OF THE AGENT

a. Why We *Need an Agent*

But if form in any motion determines matter and at the beginning of any motion exists only within the potencies of matter, it would look as though our general science of nature were running headlong into a contradiction. Whatever determines something else must be something actual; yet, in our analysis so far, the new form in any motion exists only potentially at the beginning of the motion. Form, e.g., like that of ashes, can determine matter only if it is actual, and yet at the outset of any motion, e.g., before the burning of wood, form is only potential. How can what is only potential at the beginning of a motion actually determine the matter? Clearly some new cause must now be added to make that which is only a potential determinant of matter to be an actual determinant.

The new cause in question is the efficient cause. It is the agent. It is the producer of something. It is that which, by its activity, brings about the union of form and matter or, in a better terminology, brings about the emergence of form from matter. As existing prior to change only in the potencies of matter, form cannot bring itself to an actual determination of the matter, and the matter of itself cannot make the

form to emerge since matter as such, being only potential, cannot operate. Another cause, besides the matter and form we have mentioned, is therefore necessary.[15] This is the efficient cause, the agent or mover.

b. *Hume's Doubts Concerning Efficient Causality*

Experience reveals to us that mobile beings do not move themselves under their own power.[16] Eggs do not lay themselves but require an animal of some kind as their cause. Paper will burn only when heat is applied to it from the outside. The wind blows leaves off the branches of faded plants; they do not blow themselves.

Experience thus reveals that mobile being always requires a mover or agent. It reveals even further that when an agent stops acting upon an effect, the effect stops coming into being. A builder, for instance, is necessary to build a house; and when the builder stops building, the house stops being built. When the trees are shaking, we know that something is shaking them, and when the agent stops shaking the trees, the trees themselves stop being shaken and their motion comes to an end.

Common experience, when analyzed, authorizes the induction that every motion requires a mover as surely as the convex side of a curve requires the concave. Whenever anything occurs in nature, the mind tends to ask: Who did it? or What did it? and it is confident that an answer can be found to such questions.

However, the conclusion to the existence in nature of efficient causes that actually exert an influence upon effects and bring something else into existence is strongly contested in the modern world. The author who popularized this doubt regarding efficient causality is David Hume,[17] although it was his contemporary, George Berkeley,[18] who first proposed this idea. Today this view has an influence in the life of learning that it would be impossible to calculate.

Hume was a sensist. He claimed that there is no knowledge in man except sense knowledge and thus denied that man had the supersensory power of knowing that we call intelligence. Such a view of human knowledge would deny, of course, that causes can be known. For a cause is not a sense datum. It is not something like the colored or the sweet which our external senses can apprehend. Causality is not an appearance. It is not observable and hence not open to any direct measurement (or "presentational immediacy" in Alfred North Whitehead's term [see below, n. 41]). Causality is not a thing but a dependency of

one thing on another. In our earlier language, a cause is not that which exists or operates (principium quod) but that by which something exists or operates (principium quo). Common sense would agree with Whitehead that, when a flashlight shines into a man's eye, the light makes him blink.[19] The external senses can observe the flashlight and the blinking; but causality cannot be observed. It is not the same kind of reality as an eye or light or blinking. It is not a thing but a dependency between things. But in Whitehead's language, a man "feels" or experiences that the light makes him blink.

Hume held that we do not observe causality in our experience because he refused to recognize any knowledge in man except sense knowledge. He was at least consistent in this regard. For causality, being a dependency, can be understood only by an intelligence that transcends the senses. If the senses alone could get at causality, every animal would be a scientist seeking the causes of things. Hume's central fault was to deny intelligence,[20] the power of man to grasp what things are and the power to recognize relations such as causality.

c. *Hume's Positive Position*

David Hume did more than deny our knowledge of efficient causes as real productive agents with a real influence over the effect. He proposed his own theory concerning our notions of causes. What we ordinarily call the cause-and-effect relationship, he claimed, is nothing more than regular sequences between things. He did not deny that there may be, in nature, genuine causal influences, but he affirmed that all we know about the existence of causes is regularities in temporal successions. He held that "we only learn by experience the frequent conjunction of objects, without ever being able to comprehend anything like connexion between them."[21] To interpret a previous example according to Hume's theory, it repeatedly happens, he would claim, that after light shines into human eyes, the eyes blink. Note that there is nothing observable here except a sequence of events in which one event, the blinking, repeatedly follows after another event, the flashing of light. After repeated sense experience of the sequence, light shining followed by the blinking of eyes, we are led to conclude that given similar circumstances in the future when light shines into an eye, the eye will afterwards blink.[22]

All we observe, says Hume, is a temporal sequence; and when we call the first event, the cause of the second, we are going beyond what

facts warrant. In a kindred manner, it repeatedly happens that after rain falls in the springtime various plants start growing; and we are led to expect in future cases that after the rain falls the plants will grow. According to Hume, there would be no evidence in either the light-blinking sequence or in the rain-growth sequence that the first thing is an influence producing the second. All that we can observe, says Hume, is the temporal sequence of A followed by B, "the frequent conjunction of objects, without ever being able to comprehend anything like connexion between them." What we usually call causality is thus nothing but a temporal succession where one thing follows after another but is not, as far as our observation goes, actually influenced by that other thing. After this sequence goes on often enough, the mind associates the two members together and is led to expect that after the first thing occurs the second will follow. It calls the first thing a cause of the second. But in this, according to Hume, our minds are deceived for there are no grounds to say that A, a so-called cause, is anything more than a temporal antecedent of B, the so-called effect; there is no grounds to show that B, the so-called effect, is anything more than the temporal consequent of A, the so-called cause.[23] Blume really thought that for human knowledge causality as production or influence is an illusion. There is no evidence, he argued, that efficient causality is more than a temporal sequence. Let us listen to his own language:

> When we look about us towards external objects, and consider the operation of causes, we are never able, in a single instance, to discover any power or necessary connexion; any quality, which binds the effect to the cause, and renders the one an infallible consequence of the other. We only find that the one does actually, in fact, follow the other. The impulse of one billiard ball is attended with motion in the second. This is the whole that appears to the outward senses. The mind feels no sentiment or inward impression from this succession of objects: consequently, there is not, in any single particular instance of cause and effect, anything which can suggest the idea of power or necessary connexion.[24]

d. *Criticism of Hume*

Not all aspects of Hume's philosophy are of interest here. In fact, the central error of Hume, that all knowledge is sense knowledge, cannot be discussed in the general science of nature. Of interest at present is the question of whether efficient causality, insofar as we know anything about it, can be dismissed as merely temporal sequence.

The notion that efficient causality may be nothing but temporal succession runs directly counter to human experience. In pushing a sled

up a hill, a boy is conscious that his effort is not merely a temporal antecedent of the movement of the sled but a real productive influence upon it. A carpenter, accidentally hitting his finger with a hammer, is sure to claim that the hammer is not merely a temporal antecedent of the injury but a real cause. Moreover, as Thomas Reid argued against Hume, there are many regular sequences not identified by us as causal ones, and if Hume were right in thinking that every regular sequence forced us to conclude by association that the first member of the sequence was the cause of the second, all regular successions in nature ought to be interpreted as causal ones. Night follows day, but we do not think of night as an effect of day and of day as the cause of night. In Bertrand Russell's figure, even though Chanticleer may crow every morning before dawn, no one thinks that he causes the daybreak to occur. If the mind concluded by mere association that every temporal regularity was a causal sequence, these two examples would be taken as causal. But they are not. Our mind clearly distinguishes at least in some cases between repeated successions that are temporal only and those that are causal as well. Hume's claim, that all we know of causality is temporal sequence, goes contrary to human experience.

In addition to being against the verdict of experience, Hume's whole position concerning efficient causality runs counter to human reason. To say that a thing, for all we know, can be moved without requiring the influence of a mover is really to say that a thing may move itself. Now a thing that can move itself is, by definition, self-moved and hence spontaneous in its action. Uninfluenced in its behavior by outside causes, a self-moved mobile being could do anything at any time, any place, and any way. Uninfluenced, uncontrolled, self-moved, and spontaneous, our universe of material things would be disordered and chaotic. It would not be the cosmos that experience reveals but a chaos where nothing could truly be or be known. It is because things are ordered that we know they are not self-moved and not spontaneous. They are subject to control from the outside.[25] Not being self-moved, they must be moved by an agent distinct from them. This is the efficient cause.

C. E. M. Joad has forcefully pointed out what a disordered world there would be on the premise that there is no efficient causality:

> The implications of Hume's criticism of cause and effect are incompatible with the existence of the world assumed by common sense and affirmed by science. If, in other words, Hume's criticism of causation can be sustained, then no one thing can ever be said to be the cause of any other; we have no rational basis for calculation or for prediction, since both cal-

> culation and prediction assume that the same causes will in the future produce the same effects as they have done in the past, while, so far as anticipation is concerned, we have no ground for supposing that any action may not produce the most totally irrelevant and unanticipated results. There is no more reason to expect that the explosion of the gunpowder will follow the application of a lighted match than that it will follow the impact of a jet of water, no more reason to expect that the kettle will boil when it is put on fire than when it is placed on a block of ice.[28]

In a Humean world, anything could do anything.

e. A *Final Argument*

As a final argument in support of our contention that everything requires an efficient cause it can be shown that none of the three principles of motion so far studied can explain motion adequately; hence an extrinsic mover becomes necessary.

First of all, the old form, which is to go out of existence in the motion and which has adjoined to it the privation of the new form, cannot be the cause of motion. For to the extent that the motion in question occurs, the old form or the privation becomes non-existent and hence unavailable to cause the motion.

In the second place, the subject of the motion or matter cannot cause the motion because it is potential; as potential, it cannot operate to produce anything at all: only what is actual can be a cause.[27]

Third, the new form cannot bring about the motion because the motion takes place only to the extent that the new form is not yet present. The motion terminates in the new form. Since neither the privation nor the subject nor the form can produce the motion of which they are principles, another principle, extrinsic to the mobile being, is necessary. This is the agent or mover or producer of what comes to be.[28] This principle is called the efficient cause.

f. *Divisions of Efficient Causes*

It will be necessary to return to efficient causality and to the proposition that whatever is moved is moved by something other than itself in our approach in Chapter XIX to the problem of the Prime Mover. It is in connection with this problem that the so-called principle of causality, whatever is moved is moved by something other than itself, receives its most important application, and we will be equipped by that time to give a clinching proof of the principle of efficient causality.

Efficient causes may be divided according to a fourfold plan:[29]

1. An efficient cause may be a perfecting cause, bringing a substantial form into existence after other efficient causes have prepared the way for such an existence by a suitable disposition of the matter.

2. An efficient cause may be preparatory, and, as such, it merely disposes matter for its ultimate term.

3. An instrumental efficient cause works in complete subordination to a cause other than itself. Tirus, a hammer is an instrument for a carpenter; drugs, administered in time of sickness, would be instruments for the soul of a living thing in exercising its causality upon the matter.

4. An efficient cause may be a counseling cause. This kind of causality would occur only among men where one would propose something to another in order to make the latter act.

IV. THE FINAL CAUSE

So far, then, induction has shown that there are three kinds of causes in the natural universe. There is also a fourth kind of cause, the final cause.[30] This is the end or purpose, from the Latin word finis which means end, goal, term, aim, purpose. A final cause is that for the sake of which an agent acts. It provides the explanation of why the efficient cause acts. For example, a man walks for the sake of health, and health is thus the final cause of his action. It is a cause because it is the answer to the question: why?[31]

Because the efficient cause and the final cause of mobile being are extrinsic to it, they are said to be extrinsic causes in contrast to the intrinsic causes, matter and form. There are thus four kinds of causes.[32] Tire most evident of the causes are matter and form, evident at least in the sense that without these motion could not even be represented in our intellects. Tire efficient cause is more evident than the final cause, mainly because it can be directly experienced through our own physical efforts. In some respects the final cause, at least regarding its existence, is the most evident of all the four causes, but there are many who deny this truth. In fact, it is a quite common opinion that final causality or purpose exists only in the deliberate actions of man but not in any other thing. It would be generally admitted, for instance, that a builder has a final cause in building a house or a housewife in cooking a meal or a sportsman in driving out to the golf links. But to hold that there is purpose in horses, oak trees, water, the planets, etc., is often said to be an interpretation of the world in too human a way; it is frequently

termed a case of applying to non-deliberating things principles that are valid only in the conscious, deliberate actions of man.[33]

A challenge of this sort is a serious one, so serious in fact that it will be considered throughout the next three chapters. But before undertaking that task, it will be useful to make several observations concerning the four causes.

V. DIVISIONS OF EACH KIND OF CAUSE

a. *The Divisions*

Any of the causes may be divided as follows:[34]

1. Any of the four causes may be particular or universal. A man can be said to be cured of a disease by a doctor or by an artist. Since a doctor is a particular kind of artist, the causality attributed to doctor would be particular by reference to the causality of artist, which is a more universal cause in this case since medicine is a species of art. To attribute the growth of plants to the sun would be to find a universal cause; to assign such growth to the sun's radiation would be to find a cause more proper and particular.

2. A cause may be either essential or accidental. Thus, a builder may be a musician, but the essential cause of a house is a builder as a builder rather than as something else. That the builder should be a musician or something else is accidental to the act of building, and hence to say that a musician or a war veteran built a house is to assign the accidental, rather than essential, cause. To say that a builder built a house is to give the essential cause.

3. Finally, a cause may be simple or complex. A house indeed may be attributed to many different craftsmen, to the carpenter, the mason, the plasterer, the electrician, the plumber, the decorator, etc. A house ordinarily would have a complex cause. On the other hand, a cause may be simple, as in the case of a bird that is the proper efficient cause of laying an egg.

b. *General and Special Science*

It is not the task of the general science of nature to determine in any motion what the four causes of it are and whether the causes, in any given motion, are more or less particular or universal, essential or

accidental, simple or complex. Such questions belong to special investigations. The general science of nature is thus unable to find the four causes of a horse or of gold or water, if they can be found at all. It is unable also to discriminate in these special kinds of mobile being the three modes of causality (particular or universal, essential or accidental, simple or complex) that we have just listed. All such questions require a more precise experiential and experimental investigation, aided of course by the dialectical devices that we have seen to be a preliminary to any deliberate induction.[35] The general science of nature can only propose that there are in nature the four kinds of causes we have mentioned and the three principal modes of causality that we have listed. Here again the general part of natural science may be found to provide context for the special parts, showing the specialist what he ought to look for to give a complete explanation of anything, furnishing meaningful categories for more precise and special investigation, and thus enabling all our scientific knowledges of material being to be interrelated.

To ask whether there is matter and form and agent and end in nature is one kind of question; to ask in regard to any being what its four causes are is another kind of inquiry. But the first question must be settled before the second, if more general knowledge precedes particular studies.[36]

c. *The Perfection of Physical Knowledge*

The science of nature demonstrates in terms of all four causes.[37] It is the only human science that can make this claim. Metaphysics or natural theology uses the form, the mover (efficient cause), and the end to make its demonstrations but does not employ the material cause since metaphysics leaves matter out of its considerations. Mathematics uses only the formal cause, with form taken in its meaning as essence or species.[38] But in the science of nature, demonstrations are made through the material, formal, efficient, and final causes of mobile being.

Our knowledge of anything in nature is perfect to the extent that we know all four of its causes and know them not merely in a general way but as proper to the particular kind of natural thing in question. The possession of such knowledge is an ideal for man because it is not only rare to know even a little about all of the causes of a natural thing but it is difficult to gain a knowledge of each of the causes as specific and proper to the natural thing in question. Our knowledge of nature, when it is certain, is always general; and when we try to gain more proper,

perfect, and particular knowledge, uncertainty sets in and thus makes our knowledge imperfect for another reason.

VI. SUMMARY

In passing over to this chapter, it was found that after charting out the subject of our science it was proper to inquire about the middle terms by which our science demonstrates. These are the four causes: matter and form, the intrinsic causes; and agent and end, the extrinsic causes. Both matter and form are causes because the effect depends upon them; and the form is joined to matter not by being imposed from the outside but by being evolved from within. In order to bring about this emergence or eduction, an efficient cause is necessary. However, David Hume is the author of a now rather widely accepted view that we do not know the efficient cause as a productive influence on an effect but only as a regularly occurring temporal antecedent. Causality for Hume is known only as regular temporal conjunction or sequence between two things. Hume's view is strongly opposed by experience and by reason.

The final cause or end was also mentioned to complete the list of the four causes by which natural science demonstrates. But in view of the fact that final causality is not generally held to exist in nature, it will be necessary to devote separate treatment to this problem.

REVIEW QUESTIONS

1. What is the connection between the topics treated in this chapter and the preceding subject of discussion?
2. What is a cause?
3. Show that matter and form are causes.
4. What are two meanings of the term *form* in the substantial order?
5. Why are matter and fonn called intrinsic causes?
6. How do matter and form become *united?*
7. Is there a more accurate way of speaking of this process so that the term union can be avoided? Explain.
8. In what sense can we speak of evolution, using only arguments presented in this chapter?
9. Why is it necessary to have an efficient cause for all motion?
10. Explain the position of David Hume concerning efficient causes.
11. Evaluate Hume's position.
12. Show that the three principles of mobile being are each unable to account for efficient causality.

13. State the division of efficient causes.
14. Explain what is meant by final cause.
15. How are the four causes divided?
16. What is the relation between causality as studied in the general science of nature and as studied in special branches of that science?
17. What is necessary in order to gain perfect knowledge of a material essence?

PROBLEMS

Compare the following three passages with each other and/or with the material covered in the present chapter:

I

"Every effect depends on its cause, so far as it is its cause. But we must observe that an agent may be the cause of the becoming of its effect, but not directly of its being. This may be seen both in artificial and in natural things. For the builder causes the house in its becoming, but he is not the direct cause of its being. For it is clear that the being of the house is the result of its form, which consists in the putting together and arrangement of the materials, and which results from the natural qualities of certain things. Thus a cook prepares the food by applying the natural activity of fire; and in the same way a builder constructs a house, by making use of cement, stones and wood, which are able to be put together in a certain order and to conserve it. Therefore the being of the house depends on the nature of these materials, just as its becoming depends on the action of the builder. The same principle applies to natural things. For if an agent is not the cause of a form as such, neither will it be directly the cause of the being which results from that form; but it will be the cause of the effect only in its becoming."

St. Thomas Aquinas, Summa Theologiae[39]

II

"It appears, then, that this idea of a necessary connexion among events arises from a number of similar instances which occur of the constant conjunction of these events; nor can that idea ever be suggested by any one of these instances, surveyed in all possible lights and positions. But there is nothing in a number of instances, different from every single instance, which is supposed to be exactly similar; except only that after a repetition of similar instances, the mind is carried by habit, upon the appearance of one event, to expect its usual attendant, and to believe that it will exist. This connexion, therefore, which we feel in the mind, this customary transition of the imagination from one object to its usual attendant, is the sentiment or impression from which we form the idea of power or necessary connexion. Nothing farther is in the case. Contemplate the subject on all sides; you will never find any other origin of that idea. This is the sole

difference between one instance, from which we can never receive the idea of connexion, and a number of similar instances by which it is suggested. The first time a man saw the communication of motion by impulse, as by the shock of two billiard balls, he could not pronounce that the one event was connected, but only that it was conjoined with the other. After he has observed several instances of this nature, he then pronounces them to be connected. What alteration has happened to give rise to this new idea of connexion? Nothing but that he now feels these events to be connected in his imagination, and can readily foretell the existence of one from the appearance of the other."

David Hume, Enquiry[40]

III

"Let us now dismiss physiology and turn to the private experience of the blinking man. The sequence of percepts, in the mode of presentational immediacy, are flash of light, feeling of eye-closure, instant of darkness. The three are practically simultaneous; though the flash maintains its priority over the other two, and these two latter percepts are indistinguishable as to priority. According to the philosophy of organism, the man also experiences another percept in the mode of causal efficacy. He feels that the experiences of the eye in the matter of the flash are causal of the blink. The man himself will have no doubt of it. In fact, it is the feeling of causality which enables the man to distinguish the priority of the flash; and the inversion of the argument, whereby the temporal sequence 'flash to blink' is made the premise for the 'causality' belief, has its origin in pure theory. The man will explain his experience by saying, 'The flash made me blink,' and if his statement be doubted, he will reply, 'I know it, because I felt it.'

"The philosophy of organism accepts the man's statement, that the flash made him blink. But Hume intervenes with another explanation. He first points out that in the mode of presentational immediacy there is no percept of the flash making the man blink. In this mode there are merely the two percepts — the flash and the blink — combining the two latter of the three percepts under the one term 'blink.' Hume refuses to admit the man's protestation, that the compulsion to blink is just what he did feel. The refusal is based on the dogma, that all percepts are in the mode of presentational immediacy — a dogma not to be upset by a mere appeal to direct experience. Besides Hume has another interpretation of the man's experience: what the man really felt was his habit of blinking after flashes. The word 'association' explains it all, according to Hume. But how can a 'habit' be felt, when a 'cause' cannot be felt? Is there any presentational immediacy in the feeling of a 'habit'? Hume by a sleight of hand confuses a 'habit of feeling blinks after flashes' with a 'feeling of the habit of feeling blinks after flashes.' "

Alfred North Whitehead, Process and Reality[41]

NOTES TO CHAPTER IX

1. After the subject of natural science has been determined, the nominal definitions of the middle terms of the science form the second objective of Bk. II of the *Physics.* Cf. Com. on *the Phys.,* Bk. II, les. 1, 1.
2. Cf. Chapter I, pp. 4-5.
3. Com. on *the Phys.,* Bk. I, les. 1, 5.
4. The definition of cause in the Com. on *the Met.,* could perhaps also pass for a definition of principle. Bk. V, les. 1, n. 749; les. 6, n. 827.
5. On *Truth,* q. 28, a. 7; q. 9, a. 3, reply 6.
6. Summa *Theo!.,* I, q. 14, a. 6; Com. on On Meteor, Bk. I, les. 1; Com. on the Met., Bk. VIII, les. 4, n. 1738.
7. Cf. Summa *Theol., I,* q. 85, a. 4, reply 4; Com. on *the Met.,* Bk. V, les. 2, n. 764; Coin, on the Phys., Bk. II, les. 11, nn. 4, 8; On the Power of God, q. 9, a. 1.
8. Com. on the Met., Bk. VII, les. 9, n. 1469.
9. Ibid., n. 1467.
10. John of St. Thomas, Curs. *Phil., Phil. Nat.,* I, P. Q. VI, a. 1 and Q. X, a. 3, ed. Reiner (Turin, 1930), II, 105 ff., 204 ff.
11. "Eduction" (from e-ducere, "to lead out") is unfortunately a Latinism. It is the term repeatedly used by St. Thomas. Cf., for instance, Summa *Theol., I,* q. 2, a. 8; On the *Power of God,* q. 3, a. 9, reply 3; Com. on On Meteor., Bk. I, les. 2; Com. on the *Met.,* Bk. VII, les. 7, n. 1423; On Truth, q. 5, a. 8 reply 8; Sum. cont. Gent., Bk. I, ch. 16.
12. Cf. Com. on the Phys., Bk. I, les. 12, 11.
13. On the Power of God, q. 3, a. 8, reply 5; q. 6, a. 3.
14. Com. on *the Phys.,* Bk. IV, les. 4, n. 836; Com. on the *Met.,* Bk. VII, les. 7, n. 1423; On the Power of God, q. 3, a. 8.
15. *Prin. of Nat.,* 18.
16. Sum. cont. Gent., Bk. I, ch. 13.
17. Hume's theory will be found in his Enquiry Concerning Human Understanding, cf. Hume's Theory of Knowledge, ed. D. Yalden-Thomson (Austin, 1953), pp. 2-176.
18. G. Berkeley, A Treatise Concerning the Principles of Human Knowledge, "Great Books of the Western World," XXV, 418-419.
19. Process and *Reality,* pp. 265-266.
20. Hume, op. cit., p. 16.
21. *Ibid.,* p. 71.
22. Cf. L. Foley, A Critique of the *Philosophy* of Being *of* Alfred *North Whitehead in the Light of Thomistic Philosophy* (Washington, 1946), pp. 44-45.
23. Hume's position is contained in the Enquiry, Sect. VII, pp. 61-81.
24. Op. cit., p. 64; concerning reason behind Hume's requirement for reality of cause, cf. J. Weisheipl, "Space and Gravitation," *The New Scholasticism, XXIX* (1955), pp. 176-177, n. 2.
25. Com. on the Met., Bk. 4, les. 1, n. 751.
26. Guide to *Philosophy* (New York, 1936), pp. 220-221; for another telling refutation of Hume, cf. F. Meehan, "Professor Stace and the Principle of Causality," The New Scholasticism, XXIV (1950), 398-416.
27. Sum. cont. Gent., Bk. Ill, ch. 84; Summa Theol., I, q. 2, a. 3.
28. On *Truth,* q. 5, a. 8, reply 8.
29. *Com. on the Phys.,* Bk. II, les. 5, 5.
30. Phys., Bk. II, ch. 3, 194b, 32-35.
31. *Ibid.,* 194b, 18-20.
32. Com. on the Phys., Bk. II, les. **5,** 8-11; *Prin. of Nat.,* 18-20.
33. This view is as old as Thomas Hobbes, who also permits final causality to animals, Elements of *Philosophy* in The English *Works of Thomas Hobbes,* ed. W. Molesworth (London, 1839), I, 131-132.
34. Phys., Bk. II, ch. 3, 195a, 26 ff.; Com. on the *Phys.,* Bk. II, les. 6 (passim); Com. on *the Met.,* Bk. V, les. 2 and 3 (passim).
35. Cf. Chapter VIII.
36. For the four kinds of scientific questions, cf. *Exposition of the Posterior Analytics,* Bk. II, les. 1; Com. *on the Met.,* Bk. VII, les. 17, 1651.
37. Com. on the Phys., Bk. I, les. 1, n. 5; Bk. II, les. 12 (passim).
38. Com. on the *Trim,* q. VI, a. 1, reply to the first objection.
39. Summa Theol., I, q. 104, a. 1.
40. Ed. D. Yalden-Thomson (Austin, 1953), pp. 76-77.
41. *Process and Reality* (New York, 1929), pp. 265-266.

CHAPTER X

THE CAUSALITY OF CHANCE

I. DETERMINISM

a. *Chance Not Needed: An Example*

In addition to the four causes we have mentioned so far, another cause, quite "obscure"[1] by comparison with the rest, is often alleged to exist in nature. This cause is chance or fortune. If two old friends visiting a distant city for quite different purposes accidentally would run across each other in a hotel lobby, they would probably say their meeting happened fortuitously or by chance — as though chance were the cause of the encounter. If a cow in a pasture were struck by lightning, its owner would be inclined to say the death of the animal was by accident or by chance —again indicating that chance is a cause. It is relevant, then, to ask whether chance is truly a cause and how chance is related to the other causes in nature. A consideration of chance will make a logical transition to the next chapter where the final cause, a kind of contrary of chance, will be more fully treated.

There is one school of thought, called determinism, which denies that chance is in any way a true cause. Determinism holds that the world is governed by a regularity almost mathematical in nature, to which there can never be exception.

In order to understand this point of view, let us consider a man, A, visiting another city for purposes of business and, while there, encountering an old friend, B, in a hotel lobby. A would no doubt say something to the effect that his meeting with B was by chance. But the determinist would invite us to look a little more carefully at the facts. On such closer analysis, it might be claimed that there is no cause that

can be identified as chance or luck. A went to the lobby in order to further his business, and to explain his meeting with B there seems to be no cause except this desire to register together with all of the subordinate causes intrinsically related to the fulfillment of this desire; the causes operating on A in carrying out his business plans seem entirely adequate to explain his meeting with B, and there are apparently no other causes for the encounter. Determinism would make a similar analysis of other events attributed by us to fortune or luck, and in each case it would find no evidence to assign any causality to chance.[2]

b. *Laplace's Classic Statement*

With the rapid rise of modern physics and chemistry in the eighteenth century, determinism took a more emphatic form than ever. Newton is credited with having discovered a universal mechanics whose laws applied to all bodies in the universe from the tiniest atom to the largest star. Nothing physical or natural was believed exempt from these laws, so much so that what is called chance or fortune was regarded by many followers of Newton as a case of merely not knowing how these rigid laws applied. Determinism in the nineteenth century tended to regard chance as an actual manifestation of nature's mechanical order. So-called "chance" events differ from others only because the order involved is so complicated that we are ignorant of its details. Let us listen to Laplace in a classic description of determinism:

> We ought then to regard the present state of the universe as the effect of its anterior state and as the cause of the one which is to follow. Given for one instant an intelligence which could comprehend all the forces by which nature is animated, and the respective situation of human beings who compose it — an intelligence sufficiently vast to submit these data to analysis — it would embrace in the same formula the movements of the greatest bodies of the universe and those of the lightest atom; for it, nothing would be any more uncertain, and the future and the past would be present to its eyes. The human mind offers, in the perfection which it has been able to give to astronomy, a feeble idea of this intelligence. Its discoveries in mechanics and geometry, added to that of universal gravity, have enabled it to comprehend in the same analytical expressions the past and the future states of the system of the world. Applying the same method to some other objects of its knowledge, it has succeeded in referring to general laws observed phenomena and in foreseeing those which given circumstances ought to produce.[3]

There it is. Tire world is in perfect order. And chance, far from being real, is a matter of human ignorance concerning that order. The

meeting of our two friends could have been predicted if we knew "the respective situation of" the two human beings. The death of our cow could have been predicted by an intelligence great enough "to comprehend in the same analytical expressions the past and the future states of the system of the world." According to this famous Laplacian formula, chance is not real. It is merely a matter of human ignorance. Accidents, alleged to occur in nature like the death of a cow by a stroke of lightning, really are produced by the necessity of nature's laws. Did we but know enough about these laws, such accidents, just like a solar eclipse, could have been predicted ahead of time. All such accidents are outcomes of truly unrelenting and necessary laws that operate in our cosmos. According to determinism, we call some events accidents not because of anything truly accidental in our cosmos but only because we are somehow in the dark about the way in which the necessary laws actually operate. In a familiar metaphor of Newtonian cosmology, the world is like a giant clock, and all events within that world would run their course with the unerring character of a precision-built timepiece.

So much for a sample of determinism, the doctrine which affirms a mechanical necessity in our world, denies any reality to chance, and describes the accidental as a kind of blind spot in human knowledge concerning a world that, apart from our human knowledge, is regimented by an absolute and necessary regularity.

II. INDETERMINISM

a. *Definition*

At the opposite extreme from determinism is a view that there is no necessity in nature at all and that our universe is sheerly an affair of chance. Such a view may be called indeterminism.

Like determinism, indeterminism is an old opinion. It reached back as far as the Greek atomists, Leucippus and Democritus,[4] who tried to explain the world as a complex of indivisible atoms arranged in patterns by mere chance. As Leucippus and Democritus viewed the world, chance is not only a cause but the cause of all cosmic events. By contrast to determinism which maintains that everything in the world is mechanically ordered, indeterminism maintains that there is nothing but disorder in our universe and that the cosmos we observe is the result of chance.

b. *Evidence From Biology*

Like determinism which is as old as the Greeks and as modern as Newtonian physics, indeterminism has modern as well as ancient support and possibly is the prevailing cosmology of our time. In its present form, it owes some of its popularity to the biological developments in the latter half of the nineteenth century and to the advances of physics in the first half of our own century. From biology came the theory of evolution in Charles Darwin's *Origin of Species* (1859). For present purposes, Darwin's evolutionism is important for two reasons:

1. According to Darwin, living things have as a kind of first principle a tendency to slow accidental variations; in this respect, Darwin invokes chance to explain the changes which take place as one kind of living thing gives rise to another and as one species passes over into another. Slow random change is simply part of the essence of living things.[5] It is certainly their basic drive.

2. As another important phase of his theory, Darwin proposes the notion of a "survival of the fittest": as food and other requirements for life become more scarce and more valuable, living things compete with one another in a struggle for existence. Whatever kinds of plants and animals have been favored by the accidental variations to succeed in this struggle for existence survive the competition while less favored forms of life simply perish in the conflict.[6]

In ascribing to chance or to the accidental the reason why one form of life changes into another, Darwin really takes his stand in favor of indeterminism as a theory of biological origins. But indeterminism, as a view of nature, emerges even more sharply from the physics of the present day. Three kinds of evidence for indeterminism will be passed in quick review:

c. *Evidence From Thermodynamics*

A serious break in the deterministic view of nature was made in the nineteenth century by thermodynamics, the study of heat transfer. According to the second law of thermodynamics, our universe as a whole is running downhill. Such a proposition seems quite remote from the problem of chance, and hence an explanation is in order. To connect the second law of thermodynamics with the theory of chance and randomness, it should first be observed that in any closed mechanical system some of the energy is dissipated into an unusable form of heat. Thus,

the heat that is fed into a steam engine cannot be restored to the engine to keep the system in perpetual motion; some of the output is dissipated into a form of heat, e.g., through the engine itself, and cannot be recovered by our closed system; and to keep our engine going, the heat fed into it must constantly be replenished. But we are not yet ready to apply this conclusion directly to the problem of chance.

If the universe as a whole is a closed and finite mechanical system, a steam engine on a bigger sort, then its energies even though remaining constant in quantity are undergoing qualitative changes into unrecoverable heat. The universe, in other words, is running downhill. There is a fatal conversion of energies in our universe into a lost and irretrievable heat. So at any rate says the second law of thermodynamics.[7]

According to the kinetic molecular theory, heat is the random movement of small particles. To increase heat within a system is to increase the randomness in the system; and to decrease the heat is to decrease such randomness. If the second law of thermodynamics is taken literally, the energies of the world are constantly being transformed into heat that is lost and hence unusable within that world. There is thus not only randomness in nature but a tendency to more and more randomness.

d. *Evidence From Radioactivity*

Other evidence for indeterminism in nature can be found in the phenomenon of radioactivity. In radioactive decay, chemical elements of various kinds are found, some by nature, and others under the influence of man, to emit particles or rays, and such emissions, as in the case of heat flow, are treated by statistical techniques. They are therefore considered, like other statistical phenomena, to be examples of chance and randomness. In order to show how radioactivity is considered to be a matter of chance, it should be said that every radioactive element has a so-called half-life period — the period of time during which half of the atoms present at the beginning of an observation will have broken down through radioactive emissions. Radon, a radioactive gas, has a half-life of 3.825 days. This means that within 3.825 days from our initial time of observation of an aggregate of radon atoms half of the radon atoms originally present will have disintegrated.[8]

But while the behavior of a collection of radioactive atoms can be accurately known once we know the half-life period of the element in question, there is no way of knowing which of the individual atoms from the original aggregate will break down or at what time any of the atoms

will produce an emission. The formula describing radioactivity states only that, in the half-life period of any element, half of the original atoms present will decay. It is a statistical law.

Statistics are often explained through the example of throwing a coin. Over a long period, a period say of a million random tosses, it could be safely predicted that about half of the throws would have been heads and half tails.[9] But from such a formula, nothing except probable predictions could be made concerning the individual throws; of no individual throw could there be a precise prediction that it would be heads, since the chances are even that it would be tails.[10] Somewhat like the throw of a coin, radioactivity involves an apparently statistical process; and, as such, it is often alleged as an example of chance or randomness. Because the behavior of individual radioactive atoms cannot be precisely known, it is often said that this behavior is disordered and chance-like and hence that chance is not merely a real cause but a cause that is quite common in nature.

e. *Evidence From Quantum Mechanics*

In addition to thermodynamics and radioactivity, a third series of arguments for indeterminism is based upon a system of modern physics called quantum mechanics. This is an all-embracing theory concerning the structure of both matter and energy, but it is too technical to be outlined here. Suffice it to say that, according to quantum physics, exact predictions can be made only when dealing with large aggregates of particles, just as in our much simpler problem of tossing a coin there can be an accurate prediction of, say, heads in a million throws. But just as the appearance of heads in any one throw of a coin can be predicted only with probability, so the behavior of individual particles in nature, such as electrons or protons, can be described only by the mathematics of probability. This might be illustrated by the uncertainty principle proposed by Werner Heisenberg.[11] According to the uncertainty principle, the measurement of the position of a particle always interferes with its velocity and by the same token velocity-measurement disturbs position. Because of the interference between instrument and measured object, especially in the case of small particles, a precise knowledge of nature, at the level of atoms and their parts, becomes impossible. Now where measurement is considered to be the only means of getting at nature, it cannot be said that nature follows exact laws unless that exactness can be measured.[12] Because of the Heisenberg principle and

for other but similar reasons, quantum mechanics is inclined to envision our world no longer as the rigidly determined Newtonian cosmos but as an affair of randomness and chance. The laws alleged to prevail within that world are no longer the hard and fast regularities of a precision-built timepiece, but the more elusive behavior of a statistical whole. Probability, statistics, randomness — all of these terms are familiar in quantum physics and even in the popularization of quantum physics.

It is frequently pointed out that the statistical view of nature as proposed by quantum physics is of a quite different sort from the older kinetic-molecular view of random motion. According to this older view, g., Maxwell's statistics, it would have been possible to chart the individual movements of individual molecules but much too complicated to do so. In the quantum theory, on the other hand, it is not possible even in principle to make an exact study of individual particles of very small size because our instruments will always disturb them. We must settle for probable knowledge of the positions and velocities of such particles, and this probability can never be overcome.

III. DIVISIONS NECESSARY TO OUR SOLUTION

a. Summary of *Extreme Positions*

To summarize the two extreme positions sketched so far: determinism, based in modern times upon the physics of Newton, holds to a rigidly mechanical order throughout the whole universe; chance is passed off as a mere matter of our not knowing how these rigid laws are operating in what we call "chance" events. Modern indeterminism, beginning with the biology of Darwin and supported by recent physical theory, finds chance to be a fundamental fact *of* nature. These two extreme views can bring the discussion of chance into sharper focus.

b. *Division Among Events in Nature*

In evaluating both extreme positions concerning chance and in searching out the true solution to our problem, it will be valuable to make several divisions among the events in nature, beginning, as a general science must, with the more common and more vague notions that first impress our understanding. By the proper use of division, a definition of chance can be established.[13]

1. Some events seem to happen in nature always, like the rising and

setting of the sun and the regular motion of the great dipper around the pole star in the northern skies. To such motions, no exceptions are observed, and such motions common opinion never ascribes to chance. Other events happen for the most part: higher animals are born, for the most part, with normal eyes; it usually rains in April. A third kind of event happens rarely and as an exception to other events of the same genus: thus, occasionally an animal, say a horse or a cow, is born blind; or there is an April drought. It is in this third group of events, rare and exceptional with respect to other events of the same general type, that men find what they term fortune or chance.[14]

2. A second division of events contrasts things which happen for an end and things which do not. Chance takes place only where things are working to a certain end or goal. We are expecting this aim or goal to be realized, and something unplanned occurs.[15] Let us suppose a man digging in his garden and coming upon an Indian arrowhead or even a tomahawk; he was intending one thing, the tilling of his soil, and something else, the unintended discovery of an Indian relic, came about. Such an unintended or unplanned event would be alleged as an effect or instance of chance or fortune.

3. A third division, this time within those very events that happen for an end, contrasts things which occur through deliberation and things which occur naturally. Building a house is an example of the first kind of event; the cycle of the seasons and the circulation of the blood are examples of the second type. In both deliberate and natural kinds of events men commonly find chance. Thus a builder could accidentally fall off a ladder, or circulation might become poor as a result of an accident. Both events would be ascribed to chance.

4. A final division of events is that between those which are essential and those which are accidental.[16] There is an essential connection between being a man and having a sense of humor, but many other connections are accidental only.

Such accidental connections, furthermore, may pertain either to a cause or to an effect.[17] (a) To attribute the building of a house to a musician is to name an accidental cause of the building; the house is built by a builder, the essential cause, and it merely happens that he is also a musician. There is an intrinsic and essential relation between the art of building and the house; between the house and the art of music, the connection is only extrinsic and accidental. This illustrates an accidental connection on the part of the cause, (b) Accidental connections may exist also on the part of the effect. That the house, as an

effect of building, have a roof is essential to it; that it possess weak rafters or a faulty chimney is accidental, because such defects were not planned or intended by the builder who produced the house.

This fourth type of events we have been dividing and subdividing is most critical for identifying chance or fortune. Chance is not the essential but the accidental. Moreover, for a person to be tall or musical or bald-headed is to have certain accidental characteristics; but such accidental effects are not described as chance. Chance, we have claimed, is said to be a cause. When, among those things which happen for an end, and happen frequently, there is an accidental effect of rare frequency, we attribute the cause of such an event to chance; when such an event is in the order of strictly human affairs, we call it fortune or luck.[18]

c. Conditions *Needed to Identify Chance*

For an event to be attributed to chance or fortune, several things then are necessary:

1. There must be something accidental on the part of the effect, as in the meeting of our two travelers, A and B, or in the death of a cow through a lightning bolt. The causality of such an event we ascribe to chance.

2. The event must be relatively rare, i.e., an exception to the general pattern of events of a similar kind. When an event is frequent, its causes are not attributed to chance but are considered in some way to be ordered and essential.[19] An experimenter will usually repeat an experiment at least several times so that, by getting the same result each time, he shows that he has not chanced upon some freak or other but has penetrated into an essential order obtaining within nature. Frequency of occurrence is a common sign of order and of an essential connection among causes.

3. The effect must occur in the genus of events that happen for an end. Men do not commonly speak of chance unless they are expecting some end to occur, whereas something else actually comes about.[20] There is, for example, no question of chance in the strictly mathematical order because mathematics, as we have seen, invokes formal causality only and hence has no interest in ends; connections like those in the tables of arithmetic or within the figures of geometry are always intrinsic and essential. No one would say that by chance $1 + 1 - 2$ or that by chance the sum of the interior angles of a triangle is 180 degrees. Chance cannot

affect these truths, as chance can affect a house, two travelers, the cow, etc. In other words, where there is no question of events happening for an end, there is no question of chance; and by the same token, where there is chance, there is always something that is acting for an end but becomes accidentally involved with something else acting for its own end.[21] Tire cause of this accidental connection is chance.

4. In the case of luck or fortune, the thing to which the accidental event happens must be a human being.[22] Chance among those events controlled by human will is called fortune. Good or bad luck, fortune or misfortune, are not ascribed to things not open to human control, except by some comparison or other with human affairs. It is possible to speak of a lucky horse that wins a race because winning a race is valuable not to a horse but to men; it is also possible to speak of an unfortunate animal that was killed by a car because such an accident would be considered a misfortune when happening to man. When a person thanks his lucky stars, it is he or she, rather than the stars, who is lucky. Hence, fortune is a kind of chance. Chance is a cause of relatively rare and accidental deviations from the order, executed for the most part, between a thing and its end. Fortune or luck is chance as affecting the concerns of human will.

IV. CHANCE AND DETERMINISM

a. Chance *Is the Result of Ignorance*

Further discussion of the nature and reality of chance can profitably take place by confronting the extremes of determinism and indeterminism to see whatever truth is contained in either of them.

Concerning the several aspects of determinism, it can first be conceded that at least in one sense chance as such does not exist. It is always accidental, hence relative, and since the relative lacks some absolute or fundamental quality of existence, there is a certain sense in which chance, even more than other relative things, is deficient in regard to existence itself. It cannot be said to exist in an absolute sense.[23]

Moreover, chance is truly in some way a matter of human ignorance. For one thing, failure to investigate all of the circumstances surrounding a given event may lead us to ascribe certain things to chance which are not really the work of chance at all but of hidden necessary causes; for another thing, even after a careful investigation of nature, human

reason must always remain ignorant of all the connections, actual and possible, in our world of mobile beings.[24]

In relating chance and human knowledge, or ignorance, it should be recalled that not everything accidental is chance. But chance is always among those things which are by accident; and wherever the accidental exists, there is a lack of determinism or order which makes it possible for us to have a defective understanding of the world. Now there is a necessary and determinate order between making a house and being a builder, but there is no such connection between making a house and being a musician, or being tall.[25] Consider the number of things that a builder can be besides being a builder; he can be tall or short, heavy or light, of this race or that, married or single, well dressed or shabby, belonging to this or that religion, hungry or full, and so on through an indefinitely large number of characteristics that might be added. All such characteristics are extrinsic to the art of building. They are accidental. The builder can have an indeterminate number of these characteristics besides his building art. Between being a builder and having these other qualities, there is no necessary, determinate, and intelligible connection; and, since accidental connections do not follow any intelligible law, chance, as a form of the accidental, escapes our understanding and may truly be assigned to human ignorance.

b. Chance *Is Not Only Human Ignorance*

Yet chance is not only human ignorance, as classical determinism would argue. Not all the connections in our world are necessary and determinate, as our previous paragraph pointed out. This lack of necessity and determinism, where things are only accidentally connected, is on the part *of* things themselves and not just in thought. Chance is thus as real as the indeterminism in those connections which we call accidental and extrinsic. Chance and its opposite are as objective as the indeterminate and determinate connections we find in our cosmos. The world before us is not wholly necessary and fully determinate in its causalities. The disconnectedness between being a builder and having those other qualities which are only accidental to the art of building is hence not just a discrepancy in our knowledge. Chance thus is as real as the indeterminism between the essential and the accidental in nature itself; it is as real, for instance, as the indeterminism or lack of connection between being a builder and being a musician. Hence, if chance is a matter of human ignorance, this ignorance is sometimes

occasioned by a disconnectedness in the structure of nature. Tire ignorance results from genuine discrepancies between the essential and the accidental.

c. *How Chance Is a Cause*

Unlike the house whose proper cause is a builder and unlike the oak tree whose proper cause is an acorn, chance events result not from one cause but from several, and while the builder is ordained to the building of a house and the acorn toward the production of an oak tree, there is no such order between cause and effect in those events that are caused by chance. A is in a hotel lobby in order to check his expenses; and B is there, let us say, to meet a business client for lunch. There is an order between A's presence in the lobby and his concern with expenses and another order between B's presence in the lobby and his business luncheon. Tire two orders intersect and we assign the cause of the intersection to chance. This intersection of the two orders is not itself an ordered event, i.e., flowing from a determinate and necessary cause. Rather, it is an accidental adjunct to the two lines of causality, in which each follows out its proper order and in neither of which is the meeting essentially included. In the case of the cow struck by lightning, a similar collision of two lines of causality can be discovered. The lightning tending to the ground is obeying its own proper order of causality; and the cow, grazing in the pasture, is likewise pursuing its own proper end or goal. The two orders of causality, neither of which intrinsically includes the other, crisscross with one another, and the resulting death of the cow is by chance.

Chance is not a cause but cause in the plural.[26] Chance involves at least two orders of causality in which there is no order of one to the other; both aim at some purpose other than the event which actually transpires. Many physical things result from several causes that are ordered to each other. The most obvious case might be that of an animal which is the result of at least two causes, namely the parents. However, such events are not said to be by chance. The causes are essentially ordered to each other. As a cause, chance is plural; the several causes in question are not mutually connected as are the causes, g., the male and female, in the production of an animal.

As not being ordered by the essential character of any line of natural causality, an event produced by chance has an indeterminate and disconnected causality. The concurrence of the two sequences to produce

in the one case the meeting of two friends and in the other case the death of a cow does not have a determined cause.[27] Nature ordains the food habits of a cow but not the death of a cow through a lightning bolt. Once the two series of events are under way — the two series involving in the one case the lightning and in the other case the cow — an observer from events already in motion could foresee that collision of the two series which is ascribed to chance. But when all is said and done, there is no proper reason why the series started toward each other in the first place. It is this lack of necessary relationship between the causes of things which spells chance. This undetermined causality in the physical world is what constitutes chance as something objective rather than a case of human ignorance.

c!. *Chance and Mathematical Physics*

Laplace's dictum cannot be accepted. It is so mathematical that it overlooks the physical character of chance. Chance is a reality; although men may at times, through ignorance, attribute to chance what can be truly explained by other causes, the fact remains that there is a principle for genuine chance within the universe itself. As an accidental cause of the relatively rare and unintended events affecting those things which act for an end, chance is as real as the indetermination or disconnectedness which produces the accidental collision of two causal series.

This may be the place to stress that a physics, like Newton's, which restricts itself to the mathematical aspects of the cosmos, will never by itself be able to distinguish between what is by nature and what is by chance. As our previous analysis showed, a mathematical physics is quite limited in dealing with relative and hence accidental motion, whether it be chance motion or not. Our example in this previous discussion was that of a man walking on a moving ship;[28] in relation to the shore, a man walking toward the stern at four miles per hour on a vessel moving forward at the same rate is motionless. Such is the conclusion of a purely mathematical physics.

However, when regarded from a strictly physical viewpoint, the man may be said to be in motion in a manner natural to him, i.e., he is walking. No matter what our mathematics says about his rate (a mathematical attribute) of motion, it remains a fact that he is walking, an attribute that is physical and natural for him. Briefly put, the distinction between walking and locomotion in general is a physical one; it cannot be made

in the perspective of a merely mathematical physics. In terms of another previous example,[29] where a leaf is turning green while waving in the wind, there are, once more, two motions that from a physical point of view are only accidentally related; however, from the viewpoint of a purely mathematical physics, there is no basis for saying, as we have actually been saying it, that each motion has an essential order within itself but is related to the other motion in a manner that is only accidental. Unable by itself to distinguish the essential and the accidental in the mobile world, mathematical physics by itself is unable to discuss the problem of chance.

e. Chance *and Final Cause*

Another way of stating this conclusion is to say that an approach to nature, from a mathematical or metrical point of view, does not consider the final cause or purposes of things, and because it must neglect final causes,[30] it cannot decide between events that are intended and those which are not. Mathematics rightfully takes no interest whatsoever in finality. Its subject does not require it to do so. There is no purpose to a triangle, no goal to the number 5. Whatever necessary truth such quantities may embody, the question of purpose simply does not apply to them. For a metrical or mathematical approach to nature, the meeting of our two men A and B is simply the point where two lines on a graph intersect; a similar conclusion holds for the relation between the two causal series of the grazing cow and the bolt of lightning.

But from a point of view more fundamental than mathematical physics, we have seen that we must know purpose in order to ascribe an event to chance. In a chance event, one thing is expected and something else happens.[31] A went to the hotel lobby to check expenses and B went there for a luncheon. Something not determined by either of these purposes takes place, the meeting of the two friends. It is necessary to understand that there is purpose in a sequence of events in order to recognize that there are events not determined by purpose and therefore accidental.[32] The lightning was acting for its goal, to neutralize itself; and the cow was seeking its own end also. The collision of the two series of events must be more than a point on a graph if a proper distinction is to be made between what is essential within each series and what is accidental between one and the other. Hence, it may be concluded that mathematical physics by itself is unable to understand and identify

chance. And the reason why it cannot is this: mathematical physics, as mathematical, does not take account of purpose to which chance itself is related in reality as well as in our understanding.

In order to maintain the reality of chance and in order to grasp its relation to ends or goals, it is not necessary for us to name the purposes of natural things. Whenever we find a repeated order among or within mobile beings, this effect is a sign that purpose must be at work, as our next chapter will confirm; relatively rare deviations from that order may, then, be suspected as being caused by chance. To go on from here to establish by positive proof that this or that event is by chance involves one of those dialectical processes for which no precise rules can be given. But to name the purposes of things is a different question from knowing whether things have purposes to begin with; and by the same token, our difficulties in deciding whether this or that event is by chance or by nature does not contradict the fact that chance is really different from natural causality.

V. CHANCE AND INDETERMINISM

a. *Chance Is Not a Primary Cause*

If radical determinism cannot be accepted as an account of order in the physical world, radical indeterminism merits a similar rejection. By way of justifying this conclusion, let us evaluate the arguments for indeterminism as they emerge out of biology and physics.

In Darwin's theory of evolution, it was seen, changes from one form of life to a higher one are brought about by slow accidental variations. Tire tendency to such variations is a basic characteristic of life or, in the language of this book, a first principle of living things. In ascribing the evolution of living things to slow accidental variations, Darwin made chance a fundamental cause within the living world.

But chance, while real, cannot be the primary causality in biological evolution if such evolution truly took place. Chance can exist only where there is a previous purpose or order.[33] If A in our example did not intend something other than his encounter with B, we could not call this encounter accidental; if the cow were not engaged in the pursuit of food and hence "intending" something other than being struck by lightning, there would be no meaning to ascribing to chance its death by a lightning bolt. In short, events that result from chance, however

numerous they may appear to be, must always be a secondary kind of reality because they are a deviation from an order which is more primary. One thing is "intended" and something else happens. Without a previous intention or order that chance changes, there could simply be no chance. Chance is relative and secondary; it cannot be the absolute and primary cause of all biological change. Without the more primary order which it modifies, chance could neither be real in itself nor be identifiable by us.

b. *Random Aggregations*

In addressing the problem of indeterminism, as arising out of the physics of radioactivity, thermodynamics, and quantum mechanics, it will be vital to make a distinction between chance and what can be appropriately termed randomness.[34] In order to show what this difference is, let us take a familiar example of a statistical whole — a barrelful of variously colored beans mixed so long and so thoroughly that the units of different colors are arranged in some kind of uniform pattern throughout the container. Such a uniform distribution of units in a whole is called random distribution. Beans of different colors are evenly or homogeneously scattered throughout such an aggregate.

Let us further assume that from the known dimensions of the barrel and the known size of the beans, the number of beans in the whole aggregate can be calculated to be 100,000. Let us suppose, finally, that upon drawing by appropriate means a fair sample of the beans, say 1000 of them, we find that there are 600 white beans and 400 black ones. From such a sampling, it can then be predicted that in the whole barrel there are 60,000 white beans and 40,000 black ones.[35] However, such a prediction holds for the total aggregate; the color of any one pick can be predicted only with probability. (Probability in this sense should not be confused with provability as the essence of dialectic.) Even when we know the ratio of white beans in the whole to black beans in the whole, only probable predictions can be made of individual picks. Tirus, at any one time, the probability of picking a white bean is 6/10 or 3/5 and the probability of picking a black bean on any one occasion is 4/10 or 2/5.

In a highly simplified and absolutely ideal form, this is an example of statistics. It enables us to see the kind of condition which is necessary in a statistical problem, and what statistics does and does not say about the problem of determinism.

The homogeneous or evenly distributed pattern of the beans, after a

long process of mixing, would be said to form a random distribution. But randomness is not the same as chance. For a homogeneous distribution, like that of our beans in the barrel, is truly an ordered collection. There is an order of a different kind from the one that experience usually reveals and that we normally study in our sciences, but there is order and pattern nevertheless.

c. *Randomness and Chance*

Our conclusion on this point can be confirmed by the fact that it is possible to make a mathematical analysis of a random collection. The order found to exist in the whole proves that there is an order among the individual parts even when we are unable to trace out the order itself. Statistics can be applied only to the extent that the material studied has an order.[36]

Randomness is open to scientific analysis; but chance, as such, is not. Randomness involves the mathematical; but chance is physical. Chance is a real disorder; but randomness is a disorder only for our logic, accustomed as it is to the non-statistical methods of solving problems. As a sign of its difference from randomness, chance can interfere with a random collection and thus introduce a real, physical disorder; for example, when the sampling process is interrupted and the one counting the beans leaves the room temporarily, birds or other animals could invade the bean barrel and eat an appreciable quantity of the beans, thus producing a chance disturbance of the random aggregate. Chance therefore can affect a random connection; this shows a considerable difference between chance and randomness. Randomness is a type of order which consists in indifference?[7]

Statistics become a useful substitute for more common kinds of induction when a problem becomes too complicated to handle through non-statistical techniques. Frequently, factors in a problem concerning, for instance, the structure of matter or the transmission of biological characteristics are too numerous in themselves or in their possible combinations to admit a more direct mathematical treatment. But this kind of disorder that exists when a problem must be handled by statistical means is truly a matter of human ignorance, such as the failure to understand except in terms of probability the behavior of individual beans in the above example. This "disorder" which allows only probability equations concerning individuals in a whole is only an apparent disorder. It is really an order, as the pattern found throughout the whole aggregate in our fore-

going problem would indicate. It is an order whose parts we do not understand.

Hence, the second law of thermodynamics even as treated by statistical techniques is basically an argument for order. So is radioactivity. And so indeed, with all of its paradoxes, is quantum physics. In radioactivity, for instance, our laws are unable to predict which individual atoms will decay or when any one atom will decay. But the behavior of the whole aggregate, which enables us to determine a half-life period for every radioactive element, shows that we are dealing with an order, although it is an order we do not fully understand. In regard to quantum physics, the fact that our macroscopic world is ordered proves that there is order among atoms and their parts, even if it is an order we do not comprehend.

Those who interpret modern physics as evidence that the world is disordered and chance-like reverse the logical direction for approaching nature. To ask whether order exists in nature is one kind of question; what that order is in its more precise detail is another problem which, if our previous analysis is correct,[38] occurs after the first kind of question. On this basis, the failure in the second problem to find the exact contours of the order in nature does not necessarily deny our answer to the first question, namely, that there is order in nature to begin with. If the universe as revealed to us through analyzed common experience is truly ordered, there must somehow be an order among its parts even when the parts are microscopic. For order does not spring from chance; rather chance is something secondary and relative to an already existing order. Only thus can chance be; only thus can it be understood.

VI. SUMMARY AND CONCLUSION

Our analysis has led us to reject the two extremes of radical determinism and radical indeterminism. In what sense there is a middle-of-the-road course between the two extremes will be seen in the next chapter.

The science of nature, alone among purely human sciences, demonstrates by all of the four determinate causes in nature: the material, the formal, the efficient, and the final causes. As a cause, chance is indeterminate and accidental; it is not so much a cause as it is a plurality of causes. Since chance is deficient in intelligibility, it cannot be invoked as a principle of explanation.

In the present chapter, determinism was presented as a viewpoint which ascribes unerring mechanical regularity to nature and which finds

in so-called chance only a case of human ignorance of how mechanical laws are operating. Indeterminism, on the other hand, holds to the lack of order in the physical world and maintains that chance is the basic cause of all natural things. Whereas determinism tends to find only order in the world and to deny chance, indeterminism would deny order and affirm the fundamental character of chance.

Chance was seen to be a cause of relatively rare and accidental deviations from the regular order which exists between a thing and its end. Fortune or luck is chance in matters affecting human will.

Against extreme determinism, chance was seen to be real because there is a real disconnectedness between the causes of some events, whereas other causes of events are essentially connected. There is a real difference between the accidental and the essential, and chance is as real as this difference itself. But against extreme indeterminism, it was seen that there is order in the world which is more primary than chance. In the light of our distinction between randomness and chance, it was also shown that statistics, so often taken as an argument for chance, is actually evidence of order.

For the most part, physical things follow an order; chance is the cause of deviations from that order, and such events are relatively rare. Hence, there is something to be said for both determinism and indeterminism, each in its own way and in its own place.

Chance is a kind of contrary of final causes, and with our discussion of chance now behind us, it will be appropriate to turn in the next chapter to a consideration of the final cause in natural things.

REVIEW QUESTIONS

1. Define determinism.
2. Show how determinism can claim that we do not have a distinct kind of cause called chance.
3. Explain the meaning of Laplace's famous dictum on determinism.
4. How is determinism related to Newtonian physics?
5. Define indeterminism.
6. How did Darwin contribute to the popularity of indeterminism?
7. What evidences can be gained from thermodynamics, radioactivity, and quantum mechanics in favor of indeterminism?
8. Explain how such evidence can be used to uphold that there is disorder in the world.
9. Explain in detail the fourfold division which leads us to a definition of chance.

10. Distinguish carefully among what is accidental on the part of the cause, what is accidental on the part of the effect, and chance as a cause.
11. What conditions are necessary if we are to identify an event as by chance?
12. Define chance.
13. Define fortune.
14. Explain the relation between chance and human ignorance.
15. Show how chance is real.
16. What is meant by saying that chance is not a cause but a plurality of causes?
17. Explain chance as undetermined causality.
18. Show how chance in physical things cannot be identified by mathematical physics alone.
19. What is the relation between chance and purpose?
20. Explain the difficulty of identifying chance and purpose and how this relates to whether they are each real.
21. Show how chance is relative and secondary.
22. Contrast chance and randomness.
23. How is randomness an argument for order? Explain by example.
24. Give evidence for both determinism and indeterminism in the material world.

PROBLEM

On the basis of the following news item, show the nature and reality of chance:

"Chicago — So you think you have troubles, that everything happens to you?

"Well, have you been shot by your lawnmower lately? Or by a rake? Or by a deer?

"Have you had to go around wearing a kitchen sink on your finger? Has your little girl driven the family car into the living room?

"No? Then down, boy! You haven't had it at all. For all those wacky things, and many others, happened in 1953 to people who were just as surprised as you would be if they happened to you.

"Take a look at the dizzy doings turned up by the National Safety Council in its annual roundup of odd accidents:

"Robert Heinbaugh was cutting the grass in his yard at Painesville, O., when all of a sudden he felt shot — and it wasn't from heat or fatigue. His lawnmower had run over a bullet and plugged him in the big toe.

"In Santa Cruz, Calif., John Plumbe was shot by a rake he had always regarded as trustworthy. He was raking rubbish into a bonfire. In the rubbish was a shotgun shell. Bang!

"And in Payson, Utah, Shirl Kelsey knelt triumphantly beside the deer he had just shot down. The animal kicked defiantly, struck the trigger of Kelsey's gun, and the bullet hit Kelsey in the thigh.

"Any hospital attendant will tell you that some patients bring everything

with them but the kitchen sink. Four-year-old Joan Williams of Texarkana, Ark., even brought that! She had to — it was attached to her finger! Joan had stuck the finger in the drain of the sink, and it stayed there. After simpler methods failed, her father unbolted the sink and took it and Joan to the hospital. They eventually were separated.

"Voters are asked to swallow a lot of things in a political campaign, but most of them don't go quite as far as 9-year-old Charles Scheurger of Mitchell, III., did in the last presidential election. He swallowed an 'I like Ike' button and had to go to the hospital to have it removed.

"In Memphis, Tenn., J. C. Lightfoot stood beneath a tree on a gentle day and drank deeply of the sunshine and the fresh, clean air. He was struck with the beauty of nature. Then he was struck by something else — an ear of corn dropped with precision and force by a squirrel in the branches above. Mr. Lightfoot left the beauties of nature to go home and nurse a long, deep gash in his head.

"Historians may dispute it, but the last shot of the Civil War was fired in 1953 — not 1865. It happened in the living room of the Ishmael Lynch home in Port Gibson, Miss. A Civil War shell, found long ago on a near-by battlefield, fell from a mantel and exploded, blasting holes in the floor, walls and ceiling. No Union or Confederate casualties.

"Historians also will be interested to know that George Washington and Benjamin Franklin met again in 1953 — not in Independence Hall, but in Richmond, Va. Their trucks collided on a downtown street.

"Safety experts do a lot of talking about the minimum age for safe driving. The parents of Mary Jane Rodden can tell them that two and a half years is too young. That's how old Mary Jane was the day she somehow managed to start the family car as it stood in the driveway of the Rodden home in Memphis. She had no place in particular to go, so she drove into the Rodden living room. The only thing not expensively damaged was Mary Jane. She felt fine."

Paul Jones, *The South Bend Tribune*[39]

NOTES TO CHAPTER X

1. Com. on Phys., Bk. II, les. 7, 1.
2. Ibid., Bk. II, les. 7, 2; Sum. cont. Gent., Bk. II, ch. 86.
3. *Philosophical Essay on Probabilities* (New York, 1902), p. 4. Reprinted with permission of John Wiley & Sons.
4. Phys., Bk. II, ch. 4, 196a; 1–10; Com. on the Phys., Bk. II, les. 7, 6.
5. Origin *of Species,* "Great Books of the Western World," XLIX, 23.
6. *Ibid., p.* 40.
7. A. d'Abro, *The Rise of the New Physics* (New York, 1951), I, 337 ff. This law is what L. L. Whyte means by his title, The *Unitary Principle in Physics and* Biology (New York, 1949).
8. Cf., for instance, O. Blackwood, et *al. An Outline of Atomic Physics* (New York, 1937), p. 336 ff.
9. In throwing a coin, the forces operating on the coin are different in each case. Hence the difference in

result. J. Hurzelski constructed a machine in England to flip a coin under the same conditions. He put a new six-pence piece into his device and in each throw, after flipping several times in the air and rebounding on the table, the coin landed on heads 98 out of 100 times. Then he altered the impulse and got heads up only once in a 100 throws. The aberrations in each case may have been due, it is reported, to a slight defect in the apparatus. Cf. Nature, January 27, 1945.

10. The definition of probability in terms of equal chances goes back at least as far as Hume; cf. Enquiry, pp. 57-58.
11. Cf. the description of the "ideal" experiment with a microscope and a photon in *The Physical Principles of the* Quantum *Theory* (Chicago, 1942).
12. There have been many farfetched interpretations of this principle of "indeterminism." Eddington proposed for instance that religion became possible for a man of science after 1927, the year it was shown that the universe is not a determined machine. Probability equations have been invoked in modern physics to prove free will, to refute mechanism in biology, to explain evolution; and Sommerfeld has even argued that the soul is present illocally in the body just as a corpuscle is associated with a wave in some indeterminate way. Cf. P. Frank, Interpretations and Misinterpretations of Modern Physics (Paris, 1938).
13. Phys., Bk. II, ch. 5, 196b, 10 ff.; Com. on the Phys., Bk. II, les. 8, 2-8.
14. But unforeseeability is not the essence of chance. Cf. Y. Simon, Prévoir et Savoir (Montreal, 1944), p. 22; for an analysis of the "rare," cf. C. Clark, "Spontaneity and Monstrosity in Aristotle," *The New Scholasticism,* VIII (1934), 37-38, 45.
15. What is unintended is, by itself, not necessarily by chance, Sum. cont. Gent., II, Ch. 6.
16. Com. on the Met., Bk. VI, les. 2, n. 1186.
17. Com. on the *Phys.,* Bk. II, les. 8, 8.
18. Phys., Bk. II, ch. 5, 197b, 5-7; Com. on the Phys., Bk. II, les. 8, 10.
19. *On Truth,* q. 3, a. 1.
20. For Henri Bergson, chance is always an order but a different order from the one we are expecting; cf. Creative Evolution, transi. A. Mitchell (New York, 1911), pp. 222, 232, 234, 274; for F. H. Bradley, Appearance and Reality (London, 1897), p. 234, chance is always relative to the given "system" we have in mind and, as in Bergson's argument, becomes only relative.
21. Sum. cont. Gent., Bk. II, ch. 75.
22. Phys., Bk. II, ch. 6, 197b, 5 ff.; Com. on the Phys., Bk. II, les. 10, 2-4.
23. Com. on the *Met.,* Bk. XI, les. 8, n. 2272; Summa Theol., II-II, q. 95, a. 5; cf. also J. McAllister, "Chance in Aristotle and Aquinas," Philosophical Studies in Honor of *The Very Reverend Ignatius Smith, O.P.,* ed. J. Ryan (Westminster, Md.), pp. 76-91.
24. Com. on the *Met.,* Bk. XI, les. 8, n. 2286.
25. Com. on *the Phys.,* Bk. II, les. 8, 8.
26. Summa Theo!., I, q. 115, a. 6.
27. Sum. cont. Gent., Bk. II, ch. 86; Summa *Theol.,* II-II, q. 96, a. 6; I, q. 15, a. 6; Com. on the Phys., Bk. II, les. 9; On Truth, q. 4, a. 2; Com. on On Interpretation, Bk. I, les. 14. Cf. also C. De Koninck, "Réflexions sur le problème de l'indeterminisme," Revue Thomiste, XLIII (1937), 227-252, 392-409, esp. pp. 242-243; cf. also Y. Simon, *Prévoir* et Savior, p. 26; for examples of how chance has influenced the shape of history, cf. L. Foley, "Chance and the Fortuitous in a Philosophy of History," The New Scholasticism, XXII (1948), 298-311.
28. Cf. Chapter VII, p. 133.
29. Cf. Chapter IV, p. 77.
30. Summa Theol., I, q. 5, a. 4, reply 4; Com. on the Met., Bk. III, les. 4, 375.
31. Exposition of the Post. Anal., Bk. II, les. 9.
32. Com. on the Phys., Bk. II, les. 15, 3.
33. *Ibid.,* Bk. II, les. 10, 12; Sum. cont. Gent., Bk. II, ch. 39.
34. A random distribution of the members of an aggregate may also be thought of as one in which there is

a constant relative frequency. "If a certain result occurs m times in n trials, we call *m/n* its relative frequency." R. von Mises, *Probability, Statistics, and* Truth, p. 157.

35. "The fundamental tenet of a frequency theory of probability is, then, that the probability of a proposition always depends on referring it to some class whose truth-frequency is known within wide or narrow limits." J. Keynes, *Treatise on Probability,* p. 101.
36. "Whence, the existence of statistical laws is impossible without the existence of non-statistical laws." F. Northrop, The *Logic of the Sciences* and the Humanities (New York, 1947), p. 218.
37. This is another way of saying with Hume that the members of a random aggregate have "equal chances."
38. Cf. Chapter II, supra, p. 36.
39. December 13, 1953, p. 29. Mr. Jones wrote as director of Public Information, National Safety Council.

CHAPTER XI

THE FINAL CAUSE

I. ARGUMENTS AGAINST FINAL CAUSES

a. An *Historical Note*

Of all the essential causes which Aristotle claimed existed in nature, the final cause is the most disputed and denied. At the very beginning of the modern period, René Descartes (d. 1650) proposed that the mind give up its search for final causes. He did not openly deny final causes or purposes in nature any more than Hume denied efficient causes, but held that it was hopeless to seek such causes in physical science because to do so would be to pretend an insight into the infinite and "inscrutable" counsels of God who planned our world into existence. Here are Descartes's own words:

> Already knowing, as I do, that my nature is extremely weak and limited, and that the nature of God is immense, incomprehensible and infinite, I have no difficulty in recognizing that there is an infinity of things in His power, the causes of which transcend my powers of understanding. This consideration alone is sufficient to convince me that the species of cause which we term final is not applicable in respect of physical things; for, as it seems to me, we cannot without foolhardiness inquire into and profess to discover God's inscrutable ends.[1]

Hence, while not denying that final causes exist in nature, Descartes claimed that because of the infirmity of human reason we cannot know what such causes are; the claim to know what God had in mind as the purposes of natural things would, as we read above, "profess to discover God's inscrutable ends." Actually, as we shall see, Descartes proposed a view of the world that really leaves no place for final causes.

From Descartes's time down to our own, final causality has lost the

eminence it once commanded as not only a cause but indeed the cause of all else in nature. Purpose is now no longer considered as a principle in material things. Most views of the material world in the nineteenth and twentieth centuries would agree with Immanuel Kant[2] that, although purpose plays a role in the conscious deliberation of human beings — for example, they go to school for the purpose of learning — it is illogical to conclude that there are similar plans or "intentions" in the subhuman world.

b. *Mechanism: Examples*

The most popular substitute for final causality in explaining things is mechanism. "The world," said Descartes, "is a machine in which there is nothing at all to consider but the shapes and movements of its particles."[3]

Let us see how a mechanist explains the order in the world about us. According to Lucretius, a famous mechanist of the ancient world, "Our members have not been made for our use; on the contrary, we have used them because we found them made."[4] Here is a direct clash of mechanism and final causality. Our general science of nature will claim that our hands and our feet have each been made for a purpose; our hands, for instance, were intended to make things like food, clothing, shelter, etc., and because of this purpose, they were endowed with the structure we observe in them and they were placed at our sides in order to have a freer movement than the forelegs of animals.[5] But by contrast to this view in terms of finality, the mechanist says, with Lucretius, that we proceed to use hands for purposes of making things, because they happen to have their given structure and position and we find them so made. The use simply follows upon the structure of the hands; it was not intended prior to the hands as the purpose according to which they were designed.

c. *Arguments for Mechanism*

There are several arguments in favor of mechanism:

1. In the first place, it would look as though we must endow matter with intelligence in ascribing a plan to nature. The general science of nature will argue that there is purpose or plan in the development of the human embryo, in the cycle of the seasons, in the relation of animals and plants to their environment, in the movements of the stars,

in chemical and physical change — in short, there is purpose or plan wherever there is order.[6] But to see nature as purposeful might be to ascribe to matter the ability to plan the attainment of its goals like a reasonable creature. Where a plan exists, an intelligent planner would seem required; and far from showing evidence of being intelligent, the subhuman world, even the plants and animals, presents an utter lack of intelligence. Since matter is not intelligent, it would seem illogical to claim for it purpose or plan, i.e., finality.[7]

2. As another argument in favor of mechanism, there is the dazzling progress made by physical and biological studies after they decided to ignore final causes. According to Newtonian physics, for example, the world seemed explainable by the mechanistic concepts of inertia and force with no appeal to final causes whatsoever.[8] Even biology has seemed to push deeper and deeper into the structure and function of living organisms by regarding the organisms themselves in the spirit of Lucretius. In the light of the success achieved by those modern methods of investigation which ignore final causes, these causes would seem to be unnecessary in order to explain our world.

3. Another kind of evidence in favor of mechanism is the occurrence of disorders in nature such as tidal waves, earthquakes, or typhoons.[9] Voltaire is supposed to have questioned God's existence because of an earthquake that occurred in Portugal. He could not understand, it is recorded, how a God who planned our world could include in His plans such catastrophies as earthquakes. So Voltaire was led to question that the world is planned and to doubt that God exists. For Spinoza God has to act in a manner so orderly that there cannot even be miracles as exceptions to nature's laws;[10] much less can there be chance events. For E. A Milne, a modern cosmologist, the Christian God, as rational, runs the world in a rational way, and by calling the world rational, Milne means that all things are necessary and that nothing is by chance.[11] Such thinkers, as Voltaire, Spinoza, and Milne insist that if God exists He runs the world in what amounts to a mathematical order. If you start with the premise that a Planner would rule out disorder and then discover that there are chance events, you will, like Voltaire, deny or at least doubt a plan and a Planner in the physical world.

In their scheme to explain the cosmos, mechanists always invoke the material cause and very often the efficient cause. However, since nearly all recent mechanists have accepted Hume's verdict concerning efficient causality, it is not at all clear what they mean by the agent or mover. But whatever they say about other causes, mechanists refuse to admit

the existence of final causes in nature. That is why we can characterize mechanism simply as an attempt to explain the world without recourse to final causes.

II. PROOFS FOR FINALITY

a. *No Natural Motion Is Indifferent to Its Result*

Tire final cause of a thing has three characteristics: it is that for the sake of which a thing acts; it is the good of the thing acting; it terminates the action so that the agent in question comes to rest.12

To satisfy hunger is a final cause of eating; knowledge is the goal of the human intellect. A house is the end of a builder; health, of the art of medicine; a statue, of a sculptor. In all such examples, drawn from a world very close and hence familiar in our experience, the agent acts for an end; the end is the good toward which the agent tends; and the agent, on reaching this end, terminates there by bringing his series of actions to a close. Such examples from the world of human affairs are not proposed as proof for final causality in the natural world. They are rather intended to show the meaning of our term final cause.

It is time now to prove that final causes exist in nature. Our task is to prove that nature acts for an end, i.e., that all mobile being is following out a purpose or a plan and not obeying only blind mechanical forces and factors like those which produced the "members" in the example of Lucretius. Proof for the principle of finality in nature, like many other proofs in our general science, is dialectical in character and aims at the inductive knowledge that final causes exist. There are at least five dialectical arguments toward the inductive principle that nature acts for an end.

For the first argument, let us listen to St. Thomas Aquinas:

> Were an agent not to act for a definite effect, ah effects would be indifferent to it. Now that which is indifferent to many effects does not produce one rather than another. Therefore, from that which is indifferent to either of two effects, no effect results unless it [the agent] be determined by something to one of them. Hence it would be impossible for it to act. Therefore every agent tends to some definite effect which is called its end.13

St. Thomas is proposing here that when an effect (repeatedly) follows from a given cause, we attain a sufficient reason why this is so only when we admit that the cause was ordered to produce the effect in question. If B, an effect, repeatedly follows A, the efficient cause, we

are justified in concluding that A is determined to produce B; for if A were indifferent when acting (and hence not determined to produce B) there would be no sufficient reason why B, rather than something else completely different, should repeatedly follow from A's actions. Anything indeed could follow from the action of an agent if that agent were not ordered or determined to produce this effect rather than that. The burning of wood, for instance, repeatedly produces ashes and not something else. This repeated result can be explained only if we concede that the wood, far from being indifferent to what is produced, is purposefully ordered to produce ashes under the given conditions; for if it were not so ordered and if it were indifferent to its effects, there would be no sufficient reason why ashes should always result from the activity of burning and not some completely different kind of thing.

Mechanists, of course, would agree that an "efficient" cause is determined to produce its effect. Paper, it would be said, is determined under proper circumstances to produce ashes and an egg to produce a young bird. But these (mechanistic) answers beg the question. Where an "efficient" cause, e.g., paper or an egg, is determined to an effect, the determination to the effect is not itself a cause but something that we have to explain. Such determination is not another quasi-efficient cause but precisely a datum that must be accounted for. The final cause is not another quasi-efficient cause, as Descartes would have said, but the very determinant of the efficient cause, the cause of the efficient cause, the correlative to it. Efficient and final cause are two moments of one effect, the one accounting for the production of the effect and the other accounting for its determination to be this rather than that.

Let us look at the following — and for us — dialectical syllogism: Whatever in nature occurs always or at least for the most part happens either by chance or for an end. What occurs in nature always or for the most part does not happen by chance. Therefore, such happenings are for an end.[14]

This syllogism is disjunctive. Moreover, it has contradictory alternatives so that when one alternative is denied the other can be affirmed. The burden of the argument is to employ induction for securing the minor premise: what happens always or for the most part in nature does not happen by chance. Our project requires us to admit that chance does not give a sufficient reason why one event rather than another should follow from a given action. And *if* chance is inadequate to explain why one event follows repeatedly from another, then we are obliged to conclude that only an end or goal can provide our adequate

explanation. In other words, if chance cannot explain why this effect rather than some other one is repeatedly produced by a given efficient cause, under the same circumstances, then we have achieved at least one proof for our principle that nature operates for an end.

Chance, or the undetermined causality,[15] does not give an adequate account of an effect that occurs frequently from the action of a given cause. To say for instance that the hatching and growth of young birds was not "intended" by the actions of the parents in the period preceding the laying of the eggs would mean that the parental actions, e.g., the formation and fertilization of the eggs and the building of the nest, did not "aim" at the birth and growth of the young. Tire hatching and subsequent history of the young birds would, on this supposition, have to be passed off as "unintended" and hence as the accidental result of the reproductive actions of the parents. Such actions by the parents would have to be considered as "indifferent," in the language of St. Thomas, to the outcome which actually results, indifferent, that is, to the hatching and growth of the young.

Now to say that the causal circumstances preceding the birth of young sparrows are indifferent to that birth and to say that such a birth is not intended by these preceding causal circumstances fails to do justice to the facts to be explained. The birth and growth of young birds rather than the production of some other effect repeatedly follows the reproductive actions of parents, and the only reason by which this can be explained is to admit that there is a plan, ordering the efficient causes toward these effects and not toward some other effects.[16] In other words, the parental actions of sparrows are ordained to the reproduction of their young, which is the final cause of those actions.

It would surely be considered absurd if one went about claiming that by coincidence a sparrow built a nest, by another coincidence it laid eggs that had been incidentally fertilized, by another coincidence the eggs were incubated, and by another whole series of coincidences the little birds were hatched, fed, and pushed out of the nest to fly. Common speech shows that no one could take such an analysis very seriously. When an event like the hatching of eggs occurs not just once but frequently as a result of the same kind of causal actions, it is surely necessary to assign a reason for such frequency of occurrence. To claim that by coincidence a sparrow is hatched after the series of mating and nesting actions have been completed would not explain the birth of even a single sparrow, let alone the yearly, hence frequent, repetition of this process. For when we assign an event to chance or coincidence

we are not explaining it; we are saying that it has no explanation.[17] Repetition is an order or determination; it cannot be explained by assigning causes that are indifferent or indeterminate.

While it seems absurd to attribute the orderly and even repeated reproduction of sparrows to the action of chance or coincidence, it seems quite natural and normal to ascribe to chance such events as the death of the nestlings because of a bad storm or the visit of a neighborhood cat.

Our ordinary language bears evidence that very early in its notions of the material world the human mind distinguishes between such things as the normal reproduction of sparrows and the abnormal interference with that process. Anyone who would deny this distinction would be questioning that general knowledge of nature which is more certain than any more precise and more particular notions (like Voltaire's earthquake) which would deny that there is finality in nature.

To sum up what may seem to be a rather long and complicated argument, where an event happens always or for the most part from the same cause or causes we cannot attribute that event to chance. In other words, where A's action in the same circumstances always produces B as an effect, it would be illogical to say that in these circumstances A's action is always indifferent to which effect it produces. On the contrary, the conclusion is imposed that A is determined or ordained to produce B; in other words, there is a purposeful rather than indifferent arrangement (which is no arrangement) leading from A to B, from the mating actions of sparrows to the birth of their young and from the burning of wood to the production of ashes. In fine, since the repeated occurrence of an event cannot be the result of chance, which is indeterminate causality, it can only be the result of that determinate causality which is purpose or end.

b. *In Any Completed Series, One Part Serves Another*

A second approach to finality in nature can be best achieved by setting forth, and then proving, the proposition: In any completed series of actions the prior members of the series are for the sake of the later or posterior ones,[18] for this is really another way of saying that there are final causes in nature. Observation concerning nature can show this; we have only to look at our previous example from a different viewpoint to discover that in the actions leading from the mating of sparrows to the first flight of the young there is a series of events in which the

preceding ones are for the sake of later ones. But, as dialecticians, let us begin not with natural things like sparrows but with the more familiar things of art.

In the building of a house, there is a definite order: one stage not only comes before another but is ordered to that other. The foundation is laid first so that the walls will have a proper footing; and the walls are made at least in skeletal form before the roof so that the roof can be put where it properly belongs. In the carpentry of the walls, spaces are left not only before the windows are inserted but because the windows are to come. Houses would not be what they are unless the prior stages of the construction work were not only before the later stages but for the sake of them.

Now nature reveals an order of the prior to the posterior which may be compared to the order which we observe in building. A study of the reproductive activities of sparrows would confirm this proposition. Natural things reach their perfection by a gradual process because they are all mobile beings, and in the step-by-step realization of their fullness, the preceding stages of development serve the stages to come later. In the development of embryos, it is apparent that one phase not only goes before another but prepares for it. Tire storage of food by squirrels prior to cold weather is ordered to their future wintertime subsistence as, by comparison, one part of a house is ordered to another part that will be built later. Spring not only precedes summer and its harvest but prepares for it.

One of the most remarkable indications of purpose in nature is the strange behavior of water when chilled to 4 degrees Centigrade; when it reaches this point, it does something which other liquids do not do; it expands. Thus expanded, the cooler water becomes lighter and rises to the surface, and because such cooler water is near the surface as the freezing point is actually reached, water freezes from the top down. If at 4 degrees Centigrade, water did not reverse the tendency of liquids to contract when chilled, the cooler water would always be at the lowest level of the container, and water would freeze from the bottom up.

Now why does water, when near its freezing point, suddenly reverse the behavior characteristic of liquids that are cooled? For such a phenomenon, there is no complete explanation without appeal to the final cause of preserving the fish life in the world. If water froze from the bottom of its container, our streams and lakes in colder climates would be frozen solid in the winter, and all life in such climates that depends on running water would perish also. The activity of water at 4 degrees

Centigrade is thus a crucial fact in preserving all of the higher forms of life outside the tropics. At 4 degrees Centigrade, water, like the man building a house, seems to be "directed ahead" toward a future event, the welfare of living things.

Now the mechanist confronted with the facts about the behavior of water at 4 degrees can hardly say anything except a vague Lucretian: "It just happens that way." What else could be said unless it be admitted that there is a plan or purpose or final cause for this strange behavior of water? The mechanist has to treat the expansion of water when it approaches its freezing point as a coincidence in the cosmos, and all other events which depend upon this phenomenon, such as the preservation of aquatic and even terrestrial forms of life, must likewise owe their survival to a freak. But to characterize this behavior of water by claiming that "it just happens that way" is hardly an explanation for the phenomenon; it is a begging of the question. For an explanation of the series of events that goes from the activity of water at 4 degrees Centigrade to the preservation of life beyond the tropics, the mind must turn to final causes.

The behavior of water is not the only fact uncovered by modern research to prove that, in a completed series of events, the earlier parts of the sequence are for later ones. On many counts, modern physical and biological investigations of nature have enriched our evidence that things are ordained to other things — sunlight to the process of photosynthesis, plants to animals and animals to plants in their respective respiratory processes, minerals to living things, and parts of the mineral world to other parts. Modern research has taught us more than any previous investigations how things act for the good of other things. It has reinforced the age-old conviction of men that nature operates for an end.

The final cause is just as much "observable" as the efficient cause. We know efficient causes in nature only because of the effects produced by them, and there should be no greater difficulty in working from the effects of the end to the end itself than there is in reasoning from the effects of the efficient cause to the existence and nature of such a cause. Science in the modern sense of the term is almost always concerned with the direction of motion, with evolution in biology, with entropy in physics and chemistry, with the direction of world lines in relativity mechanics, with the patterns of crystal formation, with the way in which electronic shells are formed in atoms and tissues in the development of embryos.[10] In all of these series of physical events, one stage is for the next; and the observable direction is just as much the effect of a final

cause as the physical existence of the directed events results from the efficient cause. The final cause is thus just as much of an "observable" as any other cause in nature.

C. *Art Operates for an End*

The third argument for finality in nature is again taken from human art which we have previously found to be one of our best dialectical springboards to get into the nature of things. Our argument can be **summarized as follows: Art acts for an end, and because art is an imitation of nature, nature must also be acting for an end.**[20]

Perhaps this argument sounds somewhat naïve. It looks as though we are conceiving the world entirely on the scale of human art. There may be strong evidence here of anthropomorphism, the tendency to conceive of everything not as it truly is but according to our own image and likeness as artists and hence as having purpose in our work.

But none of these charges is true. Our present argument is one of our best defenses of final causality in nature. In the first place, art in all of its various forms must rely upon a steady order in the world of nature. The aeronautical engineer, designing an airplane, cannot look upon his materials as being a mere meeting ground of coincidences. He does not, for instance, regard the aluminum planned to become a fuselage as a metal freakishly changeable from being hard to being soft, as a thing that tends to go upward one minute and down the next, as a substance with no fixed electrical characteristics. On the contrary, the design engineer of airplanes discovers in aluminum an order to fixed kinds of ends, to presence on earth for instance when not hindered by a heavier body and to a constant electrical conductivity. Since such characteristics of aluminum are constant, they are not merely coincidental. Aluminum is essentially related to them. It is ordered to them, and the airplane designer discovers that he can count on this order in making his final product. From the crudest cutting or pounding tool to the most complicated airplane or electronic device, even to ballistics missiles and an earth satellite, the manufacture of anything in the way of art depends upon the order of the material to fixed ends. The artist always in some way discovers an order in nature and turns it to his own use. Without that order on which art must count, art itself would be impossible; and because of that order which art reveals in what it works with, the materials in art can be seen to have a final cause. In other words, nature acts for an end.

The same argument can be given a different turn if we reflect on what an artist does to his natural raw materials. Arts that co-operate with nature, like medicine and farming, show that nature acts for an end; for there could not be co-operation between art and nature unless both the art and the nature were acting for the same end. If art acts for an end and if the arts that co-operate with nature do nothing but help nature along, then the nature must also be acting for an end. Moreover, even in the case of the arts that add to nature, art —always an imitation of nature — brings to "completion" an order in nature which nature is unable to "complete" for itself.[21] The electric lighting systems, in our homes and elsewhere, capture motions already existing in matter and bring them to a "perfection" which by themselves they could not attain. What is merely brought to a certain "perfection" or "completion" by art must exist incipiently and imperfectly in the raw materials with which the artist works. Action for an end in the case of art exists only more apparently and more completely than it does in the raw materials. Now even incipient and imperfect action for an end in the raw materials of art is still action for an end. If nature inchoately acts for ends that art achieves, then nature acts for ends.

Art, it was observed earlier, is never pure art. It always requires natural components, and upon such natural components it depends for whatever being it has outside the mind. If the activity of a machine is for an end and the machine depends on the materials, then the endlike action of the materials must be even more fundamental than the endlike action of the machine as a whole, even though we may not see it as well. That art acts for an end is evident even though it is derivative; that nature acts for an end may be less evident to us but in itself it is more basic.

d. *Evidence Among Animals and Plants*

Like the rest of the arguments for finality in nature, the fourth approach is destined to lead to the induction that nature acts for an end. The present argument concerns the behavior of animals. Such behavior has impressed men so forcefully not only in primitive but also in civilized society that animals have sometimes been considered intelligent creatures.[22] This is especially true in the case of animals like ants, spiders, bees, birds, and household pets. Spiders spin their nefs with a skill comparable to the dexterity of human weavers. Ants on the one hand and bees on the other work together as a group almost as though, like rational animals, they were capable of planning a truly social life. The migration of birds.

not to mention the achitecture of their nests, has always filled men with wonder. Libraries teem with books on the remarkable behavior of animals, and even today, while aware of the wonderful habits of the animal world, we usually marvel at their causes. The evidence is compelling that animals act for an end.

But, however astonishing the behavior of animals may seem to us, men alone in our natural world are truly intelligent beings. For the work of animals, though remarkable, does not show the variability which intelligence and freedom can introduce into the work of man. The nests of the various species of birds, the dams of beavers, the webs of various kinds of spiders, and other such products of the animal world are always the same in the case of the same species of animal. Swallows, for example, have been building their nests in the same way for as long as swallows have been known to man. Even David Hume could remark,

> All birds of the same species in every age and country, build their nests alike: In this we see the force of instinct. Men, in different times and places, frame their houses differently: Here we perceive the influence of reason and custom.[23]

It is evident that animals act for ends. But they are only ordered to goals. Unlike man, who has intelligence and freedom, they do not order themselves or they could vary the order. Man is such a master of his work that he designs it for himself and, designing it, can vary it. Animals thus are not rational but strictly natural creatures; however, their behavior, as witnessed by men of all times and places, shows that what is natura] acts for an end or purpose.

Even among plants there is a remarkable order which yields evidence of design and purpose. Here, too, it can be established by a clear induction that nature is ordered to an end. In the case of trees, for instance, from the roots where water and minerals are absorbed all the way to the leaves where photosynthesis takes place through sunlight, there is a unity in variety which we cal] order; many structures and functions conspire toward a unified goal, the good of the plant. The behavior of plants no less than the activity of animals provides ample inductive evidence that nature operates for an end.

e. *Form Is the End of Matter*

Another argument in favor of finality in nature can be found in the nature of form itself. Form is the end of matter, as we know from observing the order in natural motion.[24] The efficient cause can account

for the fact of the motion but not for its ordered character. Tire form that is to determine matter is the source of the order in matter's gradual disposition toward that form; the form of the young sparrow is that to which the matter in a sparrow's egg, properly disposed, really tends. If matter did not tend to the form to which it is disposed, it would reach that form only by accident. Matter is ordered to form; form is the end of matter.

As our final argument suggests, form and end are the same beings in the natural world but differ in their mode of causality.[25] The end in intention is the form when achieved. The form that is attained was "intended" by the matter as its final cause. In contemporary English, the use of idioms like form being intended by matter or like matter seeking an end may easily be misleading. Terms like these originate in our experience with human art which often provides our best dialectical scaffolding to get to nature, and frequently such a dialectical scheme cannot wholly be dismantled to allow nature to show itself as it truly is, without the introduction of human creations.

In addition to the danger of taking expressions like intention, seeking, appetite, and desire too literally when they are used of subhuman things, there is a danger in regarding the final cause as pulling its effect, somewhat as a magnet pulls metals. The causality of the end is of a different type from the other three determined causalities in nature. In the case of the reproduction of sparrows, the individual actions of the parents explain that something has happened but not why. Efficient causes, operating on matter, can account for the "content" that goes into an order but not for the order itself.[26] The final cause causes a mobile being to become, because the final cause is that toward which matter strives. Of all the causes in nature, the most important are matter and the end.[27]

III. REPLY TO OBJECTIONS

a. Chance *Events Proof Finality*

Not all of our five arguments for final causes are of equal weight. They are, of course, dialectical in character, and the reader can take his pick among them. The important thing is the induction to which our dialectic leads.

There is a sense in which finality can be established by responding to the objections which are raised against it.[28]

One obstacle to the acceptance of final causality in nature arises from monsters and freaks: animals that are born with deficient organs, plants that are stunted, tornadoes and tidal waves, earthquakes and landslides, and many other phenomena of a less spectacular nature. If nature is truly planned, how can there be abnormalities? We are confronting here the position of Voltaire, Spinoza, and Milne. The existence of monsters and freaks would seem to argue that nature is unplanned and hence without purpose. In other words, nature does not seem to be operating for an end.

In order to meet this difficulty, strength can be drawn once more from the familiar and even homely world of art. Everyone admits that art operates for an end — the grammarian, for instance, in order to express thought, the doctor in order to heal the sick, and even the mechanic in order to repair a car. If there is one thing that all artists, good and bad, have in common, it is the fact that they act for an end.

But in spite of action for an end, every artist can make mistakes. The grammarian can mispronounce or misspell a word, and the doctor can make a wrong diagnosis or prescribe a wrong medicine. Action for an end, therefore, does not rule out abnormalities. In a similar way, nature can act for an end and still allow those abnormal events that wc ascribe to chance. The objection that abnormalities in nature prove that nature cannot be acting for an end fails to establish its conclusion.

In fact, the present objection to the principle that nature acts for an end is a proof for the principle itself. Indeed, if the artists like the grammarian or the doctor were not operating for an end, it would be impossible to recognize mistakes in their art. A word, for example, is a kind of end to which a concept or idea must be ordered to be properly expressed. The sound that represents the concept man must be correctly pronounced by the good grammarian if the sound is to fulfill the end of the grammarian's art; if the word is mispronounced until it sounds like main rather than man, the grammarian has not fulfilled his aim in using an expression for man.

Now is it only because the grammarian ought to be using one sound, like man, but uses another, like main, that we can accuse him of an error. It is only because he is acting for an end and fails to attain it that we can speak of the abnormal in his art. Hence, in order to speak about mistakes and shortcomings in any art, there must be a previous awareness that the art is acting for an end.

As the recognition of grammatical error is possible only because grammar has an end, so the mistakes of a doctor who, for instance,

administers the wrong kind of medicine indicate more than ever that the art of medicine is for an end. The doctor is said to have done the wrong thing, i.e., prescribed the wrong drug only because he ought to have done something else, i.e., prescribed a different drug, according to the rules of his art. To accuse a doctor of a mistake is to insist that his art is for an end, the health of a patient, but that the means he used in order to attain this end were wrong.

In a similar way, deviations from the course of events that nature follows for the most part do not prove that nature acts without an end or purpose. They prove in fact the exact opposite. Recognition that there are aberrations in nature is a sign of our conviction that nature is acting for an end. How could there be deviations unless there were something to be deviated from? How could there be a disorder in nature unless there is an order which normally occurs and is somehow interrupted by the event that we attribute to chance?[29] In the previous chapter it was argued that chance, though real, is something secondary; it presupposes the existence of at least two series of events, both ordered within themselves and somehow crisscrossing each other. Evidence that there is chance in nature is an argument that there is order prior to chance. As the mistakes of art can be identified only because the art operates for an end, so the abnormal events in nature, far from showing nature to be purposeless, are signs of purpose itself.

b. *Mechanism Does Not Explain Order*

A second objection to the proposition that nature operates for an end is the very success of mechanism, as a project to explain the world in terms of matter and the agent, with no apparent reference to final causality. In our example of hands, which Lucretius says are found to be as they are and are used by us because they happen to have the structure and position we observe, function is the mechanical result of structure rather than a final cause of structure.

If the final cause is the cause or reason why the agent acts upon matter and if the final cause, though first in intention, is last in attainment, then the final cause, because it is last, may be regarded as a posterior cause with matter and the agent taken to be prior causes.[30] In this light, mechanism, dispensing with the causality of the end, may be conceived as a view which explains the world only by the action of prior causes. In the view of mechanism, things act, not because there is a plan of some sort to be realized, but because there are brute forces in which the

stronger asserts itself and makes the action what it is. Just as a toy balloon breaks from the pressure exerted in back of its visible surface, so motion, according to mechanism, is a kind of explosion from the sheer mechanical pressures operating on the body.

If mechanism may be regarded as a view of the world in terms of prior causes only,[31] then science in the modern sense of the term is for the most part mechanistic, and certainly one of the arguments in favor of mechanism is the remarkable success of this scientific enterprise in the living as well as in the lifeless world. Modern scientists claim that they are no longer mechanistic. This means that in quantum theory they no longer claim to find in nature the exact order or determinism which the nineteenth century deemed to be almost an axiom of the scientific method. But to the extent that the approach to nature takes place only in terms of prior causes, science even in the contemporary world is mechanistic. As an argument, then, against finality in nature there is the remarkable success of modern science in explaining the world without recourse to final causes, and the proposition that nature acts for an end would seem to be a dispensable item in our scientific study of the physical world.

Yet mechanism cannot be accepted. To view the world only in terms of its prior causes is to suppress the very reality of nature itself.[32] If mobile being is the result of mechanical forces alone, there is no intrinsic principle of motion original to each kind of material thing. Without its appetite for form, matter, as mechanism sees it, must become a kind of zero point and all reality comes to things from outside them, without the contribution of that intrinsic principle which we call nature.[33] Pure mechanism must conceive the world as pure art, which we have seen to be an impossible view of reality. The same argument can be put in another way by claiming that, in denying end, mechanism must necessarily deny form; the denial of form is a denial of matter as ordered to form, and hence under mechanism both matter and form, the principles that we have recognized to be nature, are either denied outright or badly distorted.

Plato, in his dialogue Phaedo, puts into the mouth of Socrates a telling refutation of mechanism. In order to explain why he is sitting in prison, a mechanist, according to Socrates, can do no more than describe the physiological fact that his muscles and nerves and bones are related to each other in such a fashion that he is occupying a sitting position in this place.[31] Such physiological principles, of course, are causes for the fact that Socrates is sitting in prison; but the most important cause of

the imprisonment is overlooked. This cause is the purpose of his being where he is, e.g., serving time for the charge made against him. The mechanist does not get to the real reason.

Writing of those who deny final causality, Leibniz says:

> As if in order to account for the capture of an important place by a prince, the historian should say it was because the particles of powder in the cannon having been touched by a spark of fire expanded with a rapidity capable of pushing a hard solid body against the walls of the place, while the little particles which composed the brass of the cannon were so well interlaced that they did not separate under this impact, — as if he should account for it in this way instead of making us see how the foresight of the conquerer brought him to choose the time and the proper means and how his ability surmounted all obstacles.[35]

Just as purpose or end, e.g., his serving a sentence, is the reason why the muscles of Socrates were flexed to make for a sitting position, and just as desire for victory is the reason why cannons are made and used as they are, so there is a purpose or goal for the structures we find in nature. To measure structure in nature is to get at something real but to settle for only this is like accounting for Socrates' position by describing only his muscles. Structure is for the sake of operation.

Tire order in the universe, explored by systems like that of Newton, is, like the sitting posture of Socrates or the position of cannons in a battle, an effect of the end. Indeed, only the effects of final causality can be measured. And any approach to nature which refuses to go beyond measurement cannot of itself argue to the existence of final causes, much less argue to their nature.[36] To take one example, let us look to the theory of universal gravitation. Mechanism would hold that gravitation between bodies is the force which holds the universe together. However, those who make the induction to final causality in nature see gravitational tendency as the effect of the end. Gravitation as existing in all bodies is a measure of the common tendency of all bodies to the unity of the universe.[37] It is an effect of the end, just like the sitting posture of Socrates or the firing of the cannon. If the unity of the universe is an end,[38] gravitation is a phenomenon required by the end. Without recognizing ends, we do not know the real w'hy of things.

c. *Nature Need Not Deliberate*

Another difficulty against the view that nature acts for an end is that nature does not act in a truly deliberate fashion and, at the levels below animals, nature does not even act with consciousness. Man of course acts with free will, and because he can deliberately plan a course of

action it is obvious that he acts for an end. But where deliberation is missing, hence in the subhuman and especially subanimal worlds, it would look as though action for an end is impossible.

Once more, in meeting this difficulty and in making our induction to the proposition that nature acts for an end, we can make dialectical use of the world of art in order to make our point.

It should be observed first that the better an artist the less deliberation there is in his work; and if an artist were truly perfect, he would not have to deliberate at all.[39] In learning to write, the little child at first makes a conscious and deliberate effort in every word and even every letter; but later on, as he acquires perfection in the art, he writes letters and words without deliberation and almost without being directly conscious of the process. In kindred fashion, when learning to play the piano a beginner proceeds very slowly and, once again, very deliberately — weighing his decision on almost every note and key. However, this approach in an accomplished piano player would be considered quite defective. Carrying our examples to the conclusion, we can hold that a perfect artist — whether an artist of words or notes or some other medium — would not deliberate at all because he would have perfect knowledge of the way to attain his goal. The perfect artist perfectly determines means to his end, whereas in the worker still growing in his art there is a more or less open and indeterminate grasp of the means, so that the artist must still pick and choose among them. There is no need to deliberate when the means to an end are determined.

Now nature has a determinate means to attain an end and hence it need not deliberate about them.[40] The fact that nature tends toward ends in a fully determinate but not deliberating way is a sign that there is a perfect artist that is responsible for it. It is not a part of our science to prove, by the argument from design, that such an artist exists. It is urgent here only to remark that, if nature does not deliberate, the artist of nature has deliberated for it, as metaphysics will show.

Even human art is distinct from nature because such art has its principle extrinsic to the work while in nature the principle of a work is in the work itself. If an art, like shipbuilding, were intrinsic to the materials, ships would be made by nature itself, but since ships are not made by nature, we have to trace their cause to distinct and extrinsic principles, namely human reason. Just as we have to go outside of nature to account for the determinate means to determinate ends which we find in shipbuilding, so in an even more remarkable and perfectly indeliberate order of means to ends that we discover

in nature, we must go outside of nature for our explanation. Just as we need a shipbuilder to account for ships, even more so do we need a perfect artist to account for the even more perfect ordering and certainly more basic order of means to ends that we find in nature. If nature, because it acts without the hesitancy and deliberation of an imperfect artist, is a most perfect art, there must be a most perfect artist. Hence, "nature is but the pattern of an art, namely the divine one, intrinsic to things by which these very things are moved to a determinate end."[41]

The conclusion we have just reached points to the reality of a Supreme Architect of the universe. The argument and its conclusion in the general science of nature are brought out here only to meet a difficulty because the scientific proof of the Supreme Designer of the world properly belongs to natural theology. Such proof can be treated in the science of nature only improperly and dialectically. For the science of nature, the conclusion that there is a Supreme Designer of the universe is something provable but not proved.[42]

IV. SUMMARY

Arguments against final causes urge that mechanism can explain our world. It is held, *for* instance, that if nature were subject to an end, nature would have to be intelligent. It is also argued that modern physics and biology have been very successful without recourse to final causes. Finally, the apparent disorders in nature are sometimes taken as evidence that nature is unplanned.

Arguments *for* finality, however, rest on the fact that the repeated order of an agent to its product shows that the agent is not indifferent to what it does; that in a repeated series of actions, one part serves another; that because art, as a perfection of nature, operates for an end, nature itself must be operating for an end at least imperfectly; that animals and even plants have been deemed intelligent; and that form is the end of matter.

Mechanism proves to be inadequate to explain the world. Objections based on mechanism can be answered and even used as evidence for finality.

REVIEW QUESTIONS

1. Why did Descartes banish from natural science the concern with final causes?
2. Define mechanism and give some examples of it.

3. What arguments for mechanism can be found in the need for intelligence if there is a plan to material things?
4. What argument for mechanism can be found in physical and biological studies?
5. How are monstrosities taken as evidence for mechanism?
6. Show that there is final causality in nature through the frequency of one effect from the same causes.
7. Show how various series of events manifest planning.
8. Prove that final causes exist in nature because they exist in art.
9. What evidence can be found for purpose, especially among plants and animals?
10. What evidence for final causes can be drawn from matter and form?
11. Show how the existence of monsters in nature actually proves finality.
12. What criticism can be made of mechanism?
13. Explain an argument for final causes as found in Plato or in Leibniz.
14. What application to material things can be made of these two arguments?
15. What is the relation between final causality and apparently mechanical causes like gravitation?
16. Evaluate the argument that finality in matter requires deliberation.

PROBLEMS

Compare and contrast with as much detail as possible the following mechanistic and finalistic accounts of man's bodily posture:

I

"Is it then incomprehensible that a giant primate, endowed with somewhat more courage and initiative than his fellows, should have taken a chance upon the ground? There a fall means merely getting up again, there food is infinitely more plentiful and varied, there progress is a matter of putting one foot in front of another instead of a precarious climbing from bough to bough, which gets one nowhere but out on the end of the limb. Zaccheus of the biblical story showed great perspicacity in climbing a tree but greater intelligence still in that he chose the auspicious moment in which to come down.

"Here, then, was the crucial event of primate evolution — the transformation of a tree-dwelling ape into a terrestrial biped. When our anthropoid ancestor took to the ground alternatives of posture and locomotion were offered him. The first was quadrupedal progression, the habitual gait of the gorilla, the chimpanzee and the orangutan when they leave the trees. This habit would have involved a loss of the free use of the forelimbs and might even have necessitated a redevelopment of the snout as, seemingly, in the dog-faced baboons. Such a choice might have resulted in our continuance as apes. Erect posture, on the contrary, offered every possible . . .advantage, except that of stability. Moreover our anthropoid forebears were probably already adjusted for the upright position by their previous habit

of suspending the body from the arms in brachiating and climbing up and down the trunks of trees. It has even been suggested that our arboreal line may have been somewhat deficient in arm development, so that its members were not evident brachiators.

"At any rate a series of far-reaching anatomical adaptations was necessary before man attained his present efficiency in standing, walking and running as an 'erect and featherless biped.' In the first place his center of gravity had to shift to a position above the supporting hind limbs — a result effected naturally by erecting the trunk. In order to accomplish this straightening of the body axis, the spine had to be bent in its free region between the rib cage and the pelvis. Thus originated the lumbar curve, a concavity of the vertebra] column in the small of the back which converts the spine into a graceful sigmoid shape and incidentally gives rise to innumerable backaches. Then, since the entire body weight was now transmitted to the hind limbs through the pelvis, the form of the latter had to be modified to serve this purpose, and so change also as to provide suitable surfaces for attachment of the muscles which balance the body in the upright posture. To dispense with technical detail, it may be said that the pelvis was broadened and flattened from a funnel to a basin shape. The legs became enormously elongated and strengthened in accordance with the new demands made upon them as the exclusive organs of support and locomotion. But the most radical changes occurred in the foot, which had to be transformed from a mobile prehensile member, much like a hand, to a more stable and rigid organ. Apes and monkeys can oppose their great toes (which protrude inward like thumbs) to the tips of their long outer digits. Such a movement is essential for the encircling foot grasp of boughs. It is quite useless for a flat-footed walker. The great toe was brought into line with the long axis of the foot and converted into a main point of pedal support. The outer toes, no longer used for grasping, were shortened. Tire tarsus, originally composed of loose bones like those of the wrist, was molded into a springy vault of wedge-shaped elements. The heel bone was prolonged backward to give more leverage to the great calf muscles which lift the body to the balls of the feet in walking. Thus originated the makeshift organ we call the human foot, with its easily broken down arches and its vestigial outer toes. It is essentially human; it serves its purpose more or less efficiently; but it is rarely beautiful and usually looks like a mutilated slab terminating in degenerate digits like external vermiform appendices.

"Other bodily changes consequent upon the assumption of the erect standing posture include a flattening of the chest, a broadening of the shoulders, a slight shortening of the arms and a refinement of the hands for skilled manual movements—especially an elongation and perfected opposability of the thumbs. A great transformation was wrought in the face. The protruding snout, already regressive from the transfer of its major function to the hands in prehuman primates, continued to shrink back, particularly in the region of the teeth, as these dental elements became reduced in size because they were no longer needed for defense, fo>-

offense or for the tearing of tough food. All these duties were assumed by the hands and subsequently by the sharpened tools or weapons the hands created and manipulated."

Earnest A. Hooten, ''The Upstart of the Animal Kingdom"[43]

II

"I answer that, All natural things were produced by the divine art, and so may be called God's works of art. Now every artist intends to give to his work the best disposition; not absolutely the best, but the best as regards the proposed end. And even if this entails some defect, the artist cares not. Tirus, for instance, when a man makes himself a saw for the purpose of cutting, he makes it of iron, which is suitable for the object in view; and he does not prefer to make it of glass, though this be a more beautiful material, because the very beauty would be an obstacle to the end he has in view. Therefore God gave to each natural being the best disposition; not absolutely so, but in view of its proper end. This is what the Philosopher says: And because it is better so, not *absolutely, but for each one's substance.*

"Now the proximate end of the human body is the rational soul and its operations; for matter is for the sake of the form, and instruments are for the actions of the agent. I say, therefore, that God fashioned the human body in that disposition which was best according as it was most suited to such a form and to such operations. If defect exists in the disposition of the human body, it is well to observe that such defect arises, as a necessary result of the matter, from the conditions required in the body in order to make it suitably proportioned to the soul and its operations.

"The sense of touch, which is the foundation of the other senses, is more perfect in man than in any other animal; and for this reason man must have the most equable temperament of all animals. Moreover, man also excels all other animals in the interior sensitive powers, as is clear from what we have said above. But by a kind of necessity, man falls short of the other animals in some of the exterior senses; and thus of all animals he has the weakest sense of smell. For of all animals man needs the largest brain as compared to the body; and this both for his greater freedom of action in the interior powers required for the intellectual operations, as we have seen above, and in order that the low temperature of the brain may modify the heat of the heart, which has to be considerable in man for him to be able to stand up erect. For it happens that the size of the brain, by reason of its humidity, is an impediment to the smell, which requires dryness. In the same way, we may suggest a reason why some animals have a keener sight, and a more acute hearing than man, namely, because of a hindrance to his senses arising necessarily from the perfect equability of his temperament. Tire same reason suffices to explain why some animals are more rapid in movement than man, since this excellence of speed is inconsistent with the equability of the human temperament.

"Horns and claws, which are the weapons of some animals, and toughness of hide and quantity of hair or feathers, which are the clothing of animals, are signs of an abundance of the earthly element; which does not agree with the equability and softness of the human temperament. Therefore such things do not suit the nature of man. Instead of these, he has reason and hands whereby he can make himself arms and clothes, and other necessaries of life, of infinite variety. And so the hand is called by Aristotle the organ *of* organs. Moreover it was more becoming to a rational nature, which is capable of conceiving an infinite number of things, to have the power of devising for itself an infinite number of instruments.

"An upright stature was becoming to man for four reasons. First, because the senses are given to man, not only for the purpose of procuring the necessaries of life, for which they are bestowed on other animals, but also for the purpose of knowledge. Hence, whereas the other animals take delight in the things of sense only as ordered to food and sex, man alone takes pleasure in the beauty of sensible things for its own sake. Therefore, as the senses are situated chiefly in the face, other animals have the face turned to the ground, as it were for the purpose of seeking food and procuring a livelihood; whereas man has his face erect, in order that by the senses, and chiefly by sight, which is more subtle and reveals many differences in things, he may freely survey the sensible things around him, both heavenly and earthly, so as to gather intelligible truth from all things. Secondly, for the greater freedom of the acts of the interior powers, which requires that the brain, wherein these actions are, in a way, performed, be not low down, but lifted up above other parts of the body. Thirdly, because if man's figure were prone to the ground, he would need to use his hands as fore-feet, and thus their utility for other purposes would cease. Fourthly, because if man's figure were prone to the ground, and he used his hands as fore-feet, he would be obliged to take hold of his food with his mouth. Thus he would have a protruding mouth, with thick and hard lips, and also a hard tongue, so as to keep it from being hurt by exterior things; as we see in other animals. Now such a disposition would completely hinder speech, which is the proper work of the reason.

"Nevertheless, though of erect stature, man is far above plants. For man's superior part, his head, is turned towards the superior part of the world, and his inferior part is turned towards the inferior world; and therefore he is perfectly disposed as to the general situation of his body. Plants have the superior part turned towards the lower world, since their roots correspond to the mouth; and their inferior part towards the upper world. But brute animals have a middle disposition, for the superior part of the animal is that by which it takes food, and the inferior part that by which it rids itself of the surplus."

St. Thomas Aquinas, Summa Theologiae[4]

NOTES TO CHAPTER XI

1. *Meditation* IV, in Descartes' Philosophical *Writings,* transi. N. Smith (New York, 1952), p. 234.
2. Critique of Pure Reason, transi. N. Smith (New York, 1933), pp. 521–522.
3. *The Principles* of Philosophy, Part II, n. 36.
4. On *the Nature of Things,* Bk. IV, line 22.
5. Summa Theol, I, q. 91, a. 3.
6. There is a maxim: *Ordinare rationis est* — It is the office of reason to order. Cf., for instance, Com. on the *Met,* proemium.
7. Com. on the Phys, Bk. II, les. 12, 1.
8. This ignoring of final causes, begun on the continent by Descartes, was championed by Francis Bacon, the great English rhetorician of science. "The final cause corrupts rather than advances the sciences." Novum Organum, Bk. II, ch. ii; elsewhere he calls final causes "barren." The Advancement of Learning, Bk. II, p. 142.
9. Com. on the Phys, Bk. II, les. 14, 2.
10. Ethics, in "Great Books of the Western World," XXXI, pp. 367-368, Prop. 33.
11. Modern Cosmology *and the* Christian Conception of God (New York, 1952), p. 33.
12. Com. on the Met, Bk. I, les. 4, n. 71.
13. Sum. cont. Gent, Bk. III, ch. 2, in Basic Writings of St. Thomas Aquinas, ed. A. Pegis (New York, 1954), II, 6-7.
14. Phys, Bk. II, ch. 8, 198b, 35-199a, 8; Com. on the Phys, Bk. II, les. 13, 2; Sum. cont. Gent, Bk. II, ch. 6.
15. Sum. cont. Gent, Bk. II, ch. 86.
16. Summa Theol, I, q. 2, a. 3.
17. If science is a certain knowledge of things in terms of causes, chance as being privative (cf. supra, p. 266) and uncertain (cf. supra, p. 202) cannot be involved as anything more than a secondary mode of existence (cf. supra, p. 204).
18. Phys, Bk. II, ch. 8, 199a, 9 ff.; Com. on the Phys, Bk. II, les. 13, 3.
19. Cf. B. Ashley, "Research into the Intrinsic Final Causes of Physical Things," Proceedings of the American Catholic Philosophical Association, XXVI (1952), 185-194.
20. Phys, Bk. II, ch. 8, 199a, 18-20; Com. on the Phys, Bk. II, les. 13, 4.
21. On *the Power of God,* q. 3, a. 8, reply 5.
22. Phys, Bk. II, ch. 8, 199a, 20-30; Com. on the Phys, Bk. II, les. 13, 5.
23. D. Hume, An Inquiry Concerning the Principles of *Morals* (New York, 1957), p. 33.
24. Phys, Bk. II, ch. 8, 199a, 30-33; Com. on *the Phys,* Bk. I, les. 15, 8.
25. Com. on the Met, Bk. VIII, les. 4, n. 1737; On Truth, q. 28, a. 7; q. 5, a. 2.
26. Prin. of Nat, 29; On the Power of God, q. 5, a. 1; On Truth, q. 22, a. 12.
27. For the importance of primary matter, cf. supra, Chapter VII.
28. Cf. supra, p. 214 ff.
29. Sum. cont. Gent, Bk. II, ch. 39.
30. Com. on the Phys, Bk. II, les. 15, 2; Prin. of Nat, 37.
31. Sum. cont. Gent, Bk. III, ch. 94.
32. Com. *on the Phys.* Bk. II, les. 14, 7; On *Truth,* q. 22, a. 1; cf. also J. Warren, "Nature — a Purposive Agent," The New *Scholasticism,* XXXI (1957), 364-397.
33. My Philosophical Physics (New York, 1950), p. 154.
34. *Phaedo,* 98; The Dialogues of Plato, transi. B. Jowett (New York, 1946), I, 482-483.
35. Leibniz, Discourse of Metaphysics, XIX, in Leibniz: Selections, ed. P. Wiener (New York, 1947), pp. 319–320.
36. Com. on *the Met.,* Bk. III, les. 4, n. 385.
37. On the Revolution of the Heavenly Spheres in "Great Books of the Western World," XVI, 521.
38. Com. on *the Met.,* Bk. XII, les. 12, n. 2627.
39. Com. on the Phys, Bk. II, les. 14, 8.
40. Prin. of *Nat.,* n. 19.
41. Com. on the Phys, Bk. II, les. 14, 8; cf. also On Truth, q. 3, a. 1.
42. Cf. supra, Chapter II.
43. In A *Treasury of Science,* ed. H. Shapley, S. Rapport, and H. Wright, 3 ed. (New York, 1954), pp. 488–489. Hooten's article originally appeared in The *American Scholar* (Summer, 1937), and is reprinted with permission.
44. I, q. 91, a. 3, and answers to objections.

CHAPTER XII

THE CAUSE OF CAUSES

I. THREE CHARACTERISTICS OF THE CAUSE OF CAUSES

a. *The Final Cause as Intentional*

Nature operates for an end. Though impeded from attaining its ends in those relatively rare events produced by chance, nature acts for a purpose and for the most part attains the purposes which it seeks.[1] The position set forth in the above proposition steers a middle course between the two extremes of determinism and indeterminism.

Tire final cause is not just one more cause among the others. It is the most important of the causes because it moves the efficient cause to educe form from the potentialities of matter.[2] It is the reason why the agent acts. In a more precise terminology, the final cause provides the pattern to be realized in matter by the agent; and unless we admit this pattern as somehow, somewhere pre-existing its physical realization, we have to attribute the order in our world to sheer coincidence. Because of final cause, the efficient cause operates to achieve this composition of matter and form rather than that. The efficient cause can explain that there is an emergence of form in matter but not why.[3] It is the final cause which determines the agent to act; and since the agent in turn determines the matter-form composition of the effect, the final cause is the principal or terminal cause. As controlling the causality of the agent which in turn controls the matter-and-form composition in the effect, the final cause has been fittingly termed the cause of causes.[4]

For different reasons, the two basic causes in nature are primary

matter and the end. Matter is the matrix, the raw material that is in process, and the end is the plan which is realized in matter as the process goes on. But while in one sense the end is the most fundamental cause in our universe because it causes the actions of all other causes, the mode of causing characteristic of the final cause can easily be misunderstood. While it belongs to metaphysics or natural theology to determine how the final cause causes, it may be said here at least in dialectical fashion that the final cause, as truly the final rather than the formal cause,[5] exists only in the intentional order rather than in the physical world.[6] In the physical order what exists is not end but form. End is a principle of motion; form is a termination. What was intended as end is realized as form. Frequently the science of nature, in its specialized branches, explores the effects which the final cause produces. The final cause causes things by being a source of their order,' and so whenever order is observed in nature at least something can be known concerning its cause. Tire causality of the end is that of a pattern or plan. Ultimately, this plan exists in the mind of God, the Supreme Artist; but it belongs to metaphysics to demonstrate this.

Hence, Descartes was right in associating final causes with the mind of God. But he was wrong in holding that, in natural science, final causes have no explanatory value. Actually, we know the final causes of many things — the speech organs in man, the reproductive system of animals, the seeds of plants, the behavior of water at 4 degrees Centigrade. But, strictly speaking, it is not necessary to know what the final cause of a thing is in order to know that it has a final cause to begin with. We know final causes in nature as we know the other three causes, from effects. In the case of Socrates having a sitting posture in his prison cell or in the deployment of the cannon in the campaign mentioned by Leibniz, the observable facts are explained when we know the purposes — the sentence imposed on Socrates and the desire for victory on the part of the general. In a similar way, all human science of the observable world is left incomplete to the extent that we do not trace measured data to their principles and causes in the realm of purpose. The proton and the electron combine to form hydrogen; they do so in order that hydrogen may operate as it does. The sitting posture of Socrates in prison enables us to understand how a purpose was being carried out, and the same is true in principle whenever we study the structure of matter. This structure, like the posture of Socrates, brings us at least in principle to an understanding of purpose or end. Matter is arranged as it is in order to achieve some purpose, just as the

deployment of cannon in a war can be accounted for only by the purpose of the commander in chief.

Here again is a frontier where science in the modern sense of the term meets science in our Aristotelian sense. If we know from the general science of nature that order is an indication of final causality, then the order disclosed by specialized, metrical, and experimental investigations can always, at least in some indirect fashion, reveal something about the final cause of that order. In a manner still more indirect, it can reveal something about the intentions in the mind of God.

b. *Final Cause as Terminal*

Because the final cause is intentional rather than physical in its mode of existence and in its mode of causality, the final cause is difficult to understand. But since it exercises a real influence on an effect, it is a true cause. Another reason why the final cause poses a difficulty for human analysis is that the final cause is a terminal cause;[8] that is, the final cause both terminates the motion and offers an explanation why the other three causes act as they do. The final cause itself, however, cannot be analyzed further without going outside the world where its effects are observed. In the case of a growing oak tree, we can trace the emerging form to the matter, and the motion itself to the efficient cause; the agent in turn owes its causality to the end or purpose for which it acted. But as the cause of causes, the final cause admits of no further analysis. It is an ultimate cause; it is not so much a datum to be explained, as it is the explanation for other things.

c. *Final Cause as the Good*

A third important characteristic of the final cause is that it is the good of the thing that seeks it. It is something suitable for the thing that it causes.[9] From previous remarks, it can be seen that the form of a thing is that which perfects the matter of the thing; it is that which is good or suitable to the matter. Food, for instance, is something good for the dog, water for the dry earth that is to grow plants, presence near the center of the earth for bodies that are relatively heavy and presence away from the center for bodies that are relatively light. To claim that nature acts for an end is to hold that matter always seeks what is best for it under the set of circumstances in which a change occurs.[10] Water evaporates in the heat of the sun because, under these circum-

stances, this motion is most suitable to the water; under different conditions, as suitable to its nature, water may fall as rain or snow. The lamb seeking its good flees the wolf; seeking its good, the rosebush grows to maturity and produces flowers; hydrogen and oxygen, when measured off in proper proportion and when other circumstances are right, combine to form water because this is most fitting for the matter in such conditions.

Tire final cause is thus the principal cause in nature, and the cause of causes; it is terminal because it is truly ultimate; and it is the good which the agent seeks in any action.

II. NECESSITY IN NATURE

a. *Induction and Necessity*

Final causes are the sources of order in nature. It is by relying on this order that the mind is entitled to make those generalizations which we call scientific laws: Ohm's law governing the flow of current; Coulomb's law in electrostatics concerning the attraction of charges; the gas laws of chemistry; Le Chatelier's principle in physiology. Even though such laws may be only approximations, as we noted previously,[11] they could not be formulated in quasi universal scope unless nature were ordered and unless nature were following out that plan or pattern which is final cause. Induction, the procession to a universal truth grounded upon the experience with only a relatively few particulars, thus depends on final causality; here once more our general science of nature provides a framework within which more specialized investigations can logically proceed. It is only in the knowledge that there is order and hence that there are final causes, that inductive generalizations, properly tested, can be logically justified.[12] Unless there is a necessity in natural events and hence some assurance that these events will always tend to happen in the same way, there is no basis for inductive generalization.

b. *Absolute Necessity*

In the universe of mobile beings, two kinds of necessity can be found: one is simple or absolute necessity; the other is necessity of a relative or conditional type.

Simple or absolute necessity arises from the material, formal, and

efficient causes of things.[13] These are the so-called prior causes, because they exist in reality prior to the final cause.[13] As a necessity arising from the material cause, there is an absolute necessity that an animal be destructible because it is composed of parts. As a necessity flowing from the formal cause, man must be a rational creature and a triangle (in Euclidean geometry) must have interior angles whose sum is a straight angle. Furthermore, from the point of view of efficient causality, it is necessary that there be an alternation of day and night because of the motions of the earth with respect to the sun. The necessity flowing from these prior causes, matter, form, and agent, is simple or absolute. There could be no animal that was not destructible, no man that was not rational, no relative motion of the earth that did not affect night and day. As depending on prior causes, the necessity we find in nature is simple, unconditioned, and absolute.

c. *Conditional Necessity*

Another type of necessity may be called conditional or relative; and, as the name implies, this necessity depends upon the fulfillment of certain conditions or suppositions.[14] For instance, if a house is to be built, materials must be arranged in a certain way to form the walls and roof. The walls and roof would not be absolutely necessary but necessary only on the supposition or hypothesis that a house is to be built. It is thus the final cause which is the source of this conditional or hypothetical necessity. If the house to be built is the final cause of our activity, then the materials must be arranged in such and such a way.

Returning now to nature, if an oak tree is to grow, there must be water, sunlight, and chemicals in the soil. The proposition just stated does not insist that, in an absolute sense, there must be such things as water, sunlight, and soil chemicals; it only says that these materials must be present if an oak tree is to grow. Hence, the materials are hypothetically necessary in this case, i.e., necessary on condition that an oak tree is to grow. In a similar way, walls and roof in our previous example are conditionally necessary, i.e., necessary on the hypothesis that there is to be a house.

d. *The Two Necessities Compared*

In deciding how the two necessities, the absolute and the conditional, are related to each other, let us use art again as a dialectical scaffolding.

In art, necessity exists on the part of the matter of a thing made; and a mechanical artist, in making a saw or a house, will respect this necessity.'[15] If a saw is to cut, the saw must be made of iron; if a house is to be properly built, heavier materials like concrete will be placed at the foundation and the lighter materials like wood will be placed on the superstructure. The artist will therefore respect the necessity of matter; and in this fashion he will turn it to his ends.

Necessity is thus in the matter; but the reason for the necessity is in the end.[16] The saw must be made of a hard metal, but the reason why it must be of such material is the end for which it is made. The house must be made of bricks and wood, and the reason why it must be so made is that the house must protect its inhabitants from the elements. The final cause, then, is the ultimate reason for the necessity which we saw exists on the part of matter.

Here it is also well to note that the end or final cause can, in a certain sense, be identified with the form or formal cause. The form which emerges from matter does so not just because the matter, through prior causes, happens to be disposed for it — if this were so, then the only reason for the appearance of form would be chance or coincidence. The reason why a particular kind of form emerges from the matter is found in the fact that there is an end toward which the matter is directed. In the process of becoming — on what we may call the level of coming-to-be — matter is disposed in such and such a fashion because of the end; when the form emerges from the matter, the end of the process of becoming has been realized and we can correctly say that the causal influence exercised by the end in the coming-to-be is now exercised by the form in the existing reality — what we may call the level of being.[17] The same effect is produced in matter at the level of being by the form as was produced in it by the end at the level of coming-to-be. In other words, the form which emerges from the matter and the end intended by the agent are one in being, even though distinct in causality.

Absolute necessity', as we saw, exists in matter. Since the reason for such necessity, however, resides in the end, necessity in nature is at its roots only a conditional necessity. Since all other causality depends on the end, the necessity that comes from the end is basic, and we have seen that this is only a hypothetical necessity. If trees are to grow there must be water; the necessity that there be water is thus dependent upon the condition that there are to be trees. If the seasons are to change, there must be a movement of the earth; the movement of the earth

thus depends upon an end which it serves. Nature's laws have at most only a hypothetical necessity. Tire order observed in nature is only a conditional one. If a cow is to be normal, it must have two eyes. If higher life on the earth is to exist, there must be an atmosphere. If electricity is to be generated, Ohm's law must be obeyed. Note all of the "if's" in these propositions, the grammatical signs of the hypothetical necessity which they represent. The basic source of necessity found to exist in nature lies in the final cause or purpose. Modern physics and chemistry and biology, in studying the necessary order followed by material, formal, and efficient causes, study an order and necessity whose reason is the end. As our previous discussion insisted, science in the modern sense of the term studies the effects of the principles we have been discovering in this book.

III. THE GOOD OF THE UNIVERSE

a. *The Question*

The universe of mobile beings that greets our senses is an ordered universe. We call it a cosmos, from the Greek word for order or beauty. Because of final causes, every kind of mobile being seeks an end and, unless there be an impediment, will attain that end. But because every material being operates in *a* universe where there is a plurality of motions, there may occur that interference between mobile beings whose cause is chance. Chance is the kind of exception in the course of nature which proves the rule. For the order in our world would not be nearly so remarkable were it not possible for things to behave other than they do; chance, whatever else it may be, is a reminder that things can be otherwise than they are.[18]

Chance events are exceptions in nature; the universe as a whole displays an order which argues to an end for the whole of the visible creation. What is the end of the universe, and how does that end enable us to interpret other events in the course of nature? At least part of our discussion of this point lies outside the general science of nature;[19] it may be prudently but only dialectically included here because of its supreme importance.

Is it possible to identify the good of the whole universe? Certainly it can be argued that the end of all creation is God,[20] but such a proposition cannot be established short of natural theology. Is there anything

intrinsic to the universe that can be identified as a final cause of all else within it and that of itself has no other physical finality' in the mobile world?

Such a final cause of everything else in the material world is man, or more precisely that principle of man which is his spiritual soul. This conclusion can be reached by a number of arguments.

b. *Matter's Goal: The Soul of Man*

In the purely physical sense, the soul of man is the most perfect form that prime matter can have, and if the imperfect tends to the perfect, prime matter has for its highest end the form of man. The matter of an acorn tends to the form of the oak tree; the bear cub tends toward adulthood; and so throughout the whole of nature, what is imperfect tends to be what is perfect. Although primary matter cannot produce the form of man, it can possess this form as its highest achievement; if it has an "appetite," as previously argued, it ought to tend toward the highest perfection it can own, namely the human soul.[21]

As science in the modern sense bears witness, there is a great deal of evidence that our world, lifeless as well as living, came to be as it now is by a long evolutionary ascent. The transformation of the inorganic as well as organic world from a more primitive to a more differentiated state seems highly probable. From the floor of the sea to the distant nebulae considered even now to be receding from our earth, the universe seems to have reached its present form after a tremendously long period of time and after countless evolutionary stages — the present estimate is two thousand million years.

It would be impossible to deduce evolution from principles we already know, principles like matter, form, agent, or end. None of these by themselves enable us to demonstrate that evolution has occurred as a fact. None of these principles can make our science deductive. As we have previously seen, the science of nature as it develops must constantly return to experience to find what the facts are. It is strictly empirical at base. As experience and experiment dig out new facts concerning mobile beings, the principles we have isolated so far by an induction from very general experience enable us to explain the facts. But such principles do not empower us to deduce the facts.[22]

Seen in this light, evolution can never be deduced from any of our four causes. Whether evolution has occurred depends on empirical findings, on the inductive probings of the geological record, and on our

study of such facts as embryological development in higher animals. There must be a fact-finding phase before principles can be applied to explain the facts. But once determined as highly probable by means of empirical investigation, evolution can be explained by principles of the sort we have studied, namely, the four causes. Biologists and geologists, although sure that evolution in some form probably did take place, are by no means close to the causes needed to explain the evolutionary advance. One of these causes is the end, and another is primary matter, the two principles that we have considered most basic in the world of nature. It can be strongly argued that since the soul of man is the highest form that primary matter can attain, this matter should be constantly disposed step by step to receive that form.[23]

Here then are two of the principal reasons for the probable fact of evolution: **Primary matter,** or the material cause, is engaged in a passage toward its **highest end,** and, like anything physical that is struggling toward perfection, it reaches its end only gradually.[24] It is no explanation of evolution to say that changes occur by chance, for unlike primary matter and end, chance is not a primary cause in nature. If blind mechanical struggle were the cause of survival, evolution and even the appearance of man would have to be attributed to the necessity of the matter — just as without an end heavier materials would be at the bottom of a house not because of a plan but only through the necessity of the matter. Evolutionists often portray our world as a titanic struggle for power in which the most mechanically superior forces come through while the weaker perish. How could a struggle giving victory merely to the most powerful ever produce man, in some sense the weakest of all animals? Neither chance nor struggle[25] can account for the facts which Darwin and his successors have marshaled for evolution. To explain evolution, it is necessary to go to the principal causes of nature, the final cause and the material cause. If primary matter tends toward the highest form it can own, it should tend toward the soul *of* man. Tire soul of man is the end of matter. Even matter has a spiritual good.[26]

Common observation reveals a general tendency throughout the world for lower things to serve higher ones: plants use the minerals; animals use both; higher animals use lesser ones; and man uses all of the great realms of being that lie below him.[27] For the plant to transform the mineral, for the cow to consume the grass, for the big fish to eat the little fish is always for the good of matter and eventually for the good of man. We do not understand the particular ways in which these processes serve man. How does the eating of a little fish by a big one

contribute to man's soul? What is the connection between a boa constrictor or an ostrich and the good of man, save that they perfect our knowledge of the nature of God? None of these questions have been answered in any but a common way. Some of them may never be answered by man in his present state. But our failure to discover precisely how other things in the physical world bear upon man's good cannot lead us to deny that they have such a bearing. Our argument that man is the end of the physical world is based not upon this or that example of things serving man but upon the very character of primary matter and of final cause. Having a lower form, matter somehow tends to a higher form until it reaches man.

c. Alan's *Mind as the End of Matter*

Besides evolution with its account of how matter is prepared to receive the human soul, there are other arguments that man is the end of the material world. The universe exists for man to know in order that, knowing it, he might eventually know himself and also know God as the cause of all other things. Whatever lies in the subhuman world is closed in upon itself by spatial and temporal boundaries. A thing that is here must be here only rather than also in some other place; what happens now happens only now and cannot happen again. Even the animals can know only one thing at a time with their various sense powers. They are determined within the limits of this place or this time that they are apprehending, and they cannot break out of this determination.

But because of his intellect, man can take in many things. In principle, he can take in the whole universe. Knowledge that motion requires matter and form concerns not merely this localized thing which occupies the attention of this animal or that localized thing which attracts some other animal. In knowing matter and form, we know something of the principles of all motion. Man thus takes many things into consideration; indeed, he can take in the whole universe. He draws the whole world together in his mind and thus brings into our cosmic surroundings that highest form of unity or order which is intellectual knowledge.[28] Listen to St. Thomas Aquinas on this point:

> . . . the perfection of each individual thing considered in itself is imperfect, because it is a part of the perfection of the entire universe, which arises from the sum total of the perfections of all individual things.
>
> In order that there might be some remedy for this imperfection, another

> kind of perfection is to be found in created things. It consists in this, that the perfection belonging to one thing is found in another. This is the perfection of a knower in so far as he knows; for something is known by a knower by reason of the fact that the thing known is, in some fashion, in the possession of the knower. Hence it is said in The Soul that the soul is, "in some manner, all things," since its nature is such that it can know all things. In this way it is possible for the perfection of the entire universe to exist in one thing.[29]

Human knowledge is thus a unifying principle within the universe. Tire order or unity of physical things in some manner reaches its highest level in the soul of man where all of the perfections of material things can be brought together in one view. Man thus brings into the universe the greatest of its perfections because his mind can unite all of its perfections. If the imperfect tends to the perfect, other things tend to him.

d. *Questions About Matter Are Questions About Man*

As a consequence of what has just been said it should be observed that the human soul is the principle of all of the intellectual, sensitive, vegetative, and physical activities which man exhibits.[30] It is the cause of thinking and willing, of sensation and the emotions, of nutrition, growth, and reproduction, and of the structures that result also from the soul's causality on primary matter. Man embodies all the generic perfections of the world below him; he performs activities shared by all of the three lower orders of visible creation. The more we know about the powers of physical, vegetative, and sensitive reality, the more we can know about ourselves who embody all of these orders.

Moreover, in addition to being the principle of chemical, vegetative, and sensitive activities, the soul of man is intellectual. By his intellectual soul, man thinks and wills. In this regard, man stands at the confines of eternity, having a spiritual form that as a form has something in common with material things and as a spirit has something in common with angels. Man is thus a kind of natural mediator between terrestrial and celestial things, a being that is both animal and rational. Tire soul is the principle of union between the material and spiritual realms in that metaphysical hierarchy of being extending from primary matter, as pure potency, to God, who is pure act. At any rate, the study of man's soul gives us our best introduction to a knowledge of the higher grades of being. The soul of man is the limit of one universe and the beginning

of another. **All other creatures in the world contribute to man's knowledge of himself.**

As additional evidence that questions about the material world are in their last analysis questions about man's soul,[31] it will be noted that almost every discovery within the physical world is used by man to inquire about his own meaning. Such discoveries have repercussions concerning man's origin and his destiny and his code of conduct. Thus the theory of evolution, especially as it developed in the hands of naturalists who argue that there is nothing but chance and struggle in living things, has been used as evidence that man is merely one among other animals. Relativity theory provoked men to ask whether there are any absolutes in human conduct. The fact that atoms behave according to statistical laws and with a kind of "freedom" has been taken as proof that man is free. Since everything is free, the argument runs, surely man is free. The discovery of viruses, apparently transitional creatures having some of the properties of living things but also some of the properties of lifeless reality, has prompted men to ask about the distance between life and non-life; it has provoked questions about our own difference, as living things, from merely mineral reality. It was long ago stated that when Copernicus argued that the earth was not the center of the world, man could no longer be regarded as the center of creation. Whether there is life and even human life on other planets is a question that somehow affects man's estimate of himself within the visible world. Truly all questions concerning lower creatures are bound up with a central question, What is man? And all this is evidence that man is somehow the most important creature in the world toward which all others, in some way or other, contribute. Man is the aim of matter.

e. *The Use of Matter*

Man was made not only to know the material world but also to use it. To other things, nature provides a sufficiency for life. Animals are provided with a coating for their skins, with fur, hair, feathers; they have claws to dig for food and shelter and to defend themselves against attack; they have by nature the power to live outdoors and frequently in extremes of temperature. In other words, their natural powers are ready-made for their survival and success. They do not have to produce works of art to add to what endowments nature has given them.

But man is in a certain way less favored by nature. He has a highly

delicate body, is prey to numerous diseases, needs clothes, and is unable to move about with the agility of other animals. But, on the other hand, man has been equipped with reason and hands; and by virtue of these two possessions, man can make for himself the clothes, tools, dwellings, and other things needed by him and which nature has provided ready-made for other animals. He not only can use nature; he cannot avoid doing so. He is required to make more or less complicated works of art, those extensions of his natural powers that we have previously characterized as imitations of nature. In thus using nature, man avails himself of all levels of the material world from the higher animals that supply food and pelt to the sands of the sea that he mixes into his mortar and his concrete. It is not a mere luxury for man to use the world below him; it is natural and necessary.[32]

Since a thing used is a means for the user, the user is its end. Matter serves man,[33] and hence man is the goal of matter.

The deeper our penetration into nature the more we have been able to use the material world. Tire theoretical discoveries of one age of science in the modern sense of the term have been applied in the next age to engineering and medicine to produce new instruments for human use or new means of fighting disease. In fact, when it is not set within the context of first principles, it is difficult to see how science in the modern sense can hardly be more than a preparation for art even when that science is engaged in so-called pure or basic research. Man today has more resources to control nature than ever before. But because the discoveries of science in the modern sense have been taken out of the total context that could supply them with meaning and direct them to man's total good, there is the awful possibility that the most powerful tools that man has ever made may be turned not toward his good but against it. The causality of the end gives meaning to man and to man's discoveries just as it gives meaning to the material structures in the world itself. But with the development of modern science in a world that was losing respect for final causality, man's use of matter has finally reached a point where all civilization is in peril.

It is not likely that man will use nature wisely and well unless he knows his own place in nature; but for man, through his unaided reason, to know his place in nature, it is first necessary for man to have general and certain knowledge about nature itself. This he gains from a study of the principles elucidated thus far in this book.

IV. MOTION TENDS TO PERMANENCE

a. *Struggle Is an Effect*

To see a universe where primary matter aims at the soul of man is to sketch out a quite different world from the one seen by modern naturalism. According to naturalists, evolution is interpreted as an affair of stresses and strains. There is a constant tension among things that may be best summed up as a struggle for existence. To hold, as we have done, that there is final causality in nature does not demand closing our eyes to the element of struggle in the world. The fact of struggle is easily seen by induction; it is a matter of personal observation and experience. But just as chance, the fundamental cause of change in Darwinian evolution, is in truth only a secondary kind of causality, so the struggle for existence as the reason for survival of one form of life rather than another is truly secondary. Two animals will struggle for food because they are working for the same end. Their action for an end is primary, and struggle is a secondary phenomenon. One animal will kill a plant or another animal because it needs this plant or animal to fulfill its end; once again, the end is primary. In the lower world and even in the case of human conflicts between men and within men, struggle is always a by-product of the order of things to their ends.[34]

b. *The Struggle for Survival*

Like chance, which is taken to be the cause of change in Darwinian evolution, struggle, which Darwin alleges as the cause of survival, cannot be a primary cause. It is always a consequence, always an effect; and as long as there is a universe where the lower works for the higher, there will be always struggle and pain in order that a greater good might come about and in order, somehow, that man's interests may be finally served. The wolf attacking the lamb seeks its own good; and likewise seeking its good, the lamb for its part resists the wolf as far as it can. From one angle, everything tends to resist change because everything tends to preserve itself in being. Everything tends to retain its integrity. Everything tends to stand firm against destructive agents.

c. *The Survival of Man*

Now in the soul of man, an indestructible and immortal substance, the common tendency in all things to preserve themselves at last attains

victory and success.[35] The form of man's matter, truly imperishable, attains that perpetuity at which our universe under all other forms unsuccessfully aims. The mobile world would thus be drastically incomplete without man. Without him, it would be unsuccessful and would have no sufficient reason for existence. Man is, therefore, the end of the universe. He represents the success of all material things in the struggle of motion toward permanence.

Put into a simpler form, movement by its nature cannot be regarded as an end since it is always a tendency to something else.[36] As an act of the imperfect, movement makes sense only in relation to some ultimate perfection, something that is immobile rather than mobile and permanent rather than transitory. Since the soul of man is the only permanent and immobile substance in the material universe, the soul of man is the end of matter. If such a view appears strange in a world that often takes nature to be hostile to man or at least indifferent, it is a sign of how far our thinking may have strayed from a proper conception of our own meaning and destiny.

V. SUMMARY

In this chapter, the final cause was seen as the cause of causes, bringing the efficient cause to effect this or that union of matter and form. As the most truly causal among all the causes, the final cause accounts for the basic kind of necessity in the material world, namely, hypothetical or conditional necessity. Without finality, all necessity would be of the absolute or unconditional type, and such absolute necessity would be without sufficient reason. In a more concrete setting, this chapter showed the cause of causes in the material world to be the soul of man because the human soul is the aim of primary matter in development, because man's mind in knowing the universe unifies it in an eminent way, and because materia] things are made for human use.

REVIEW QUESTIONS

1. Explain what is meant by calling the final cause "intentional."
2. Explain how the final cause "causes."
3. How can the findings of science in the modern sense relate to final causality?
4. Why is the final cause terminal?
5. Explain what is meant by the good and why the final cause of a thing is always some good.
6. Why is the final cause called the cause of causes?

7. How is induction related to final causality?
8. Explain the two kinds of necessity in nature.
9. What is the source of each kind of necessity?
10. How are the two necessities related to each other?
11. Which of the two necessities is fundamental?
12. What does it mean to ask about the intrinsic good of the universe?
13. Show how the soul of man can be called the goal of matter's development.
14. What is the relation between final causality and evolution?
15. Can evolution be deduced? Explain.
16. Can the causes studied by biology explain evolution? Why or why not?
17. How can it be shown that man's mind is the end of the material universe?
18. Show how questions about nature are in the last analysis questions about man.
19. Show how the material world was intended for human use.
20. Show how struggle, like chance, can be at most a secondary causality in nature.
21. How can the tendencies of primary matter be evidence for the argument that man's soul is immortal?

PROBLEM

Explain the following passage:

"As we said, since any moved thing, inasmuch as it is moved, tends to the divine likeness so that it may be perfected in itself, and since a thing is perfect in so far as it is actualized, the intention of everything existing in potency must be to tend through motion toward actuality. And so, the more posterior and more perfect an act is, the more fundamentally is the inclination of matter directed toward it. Hence, in regard to the last and most perfect act that matter can attain, the inclination of matter whereby it desires form must be inclined as toward the ultimate end of generation. Now, among the acts pertaining to forms, certain gradations are found. Thus, prime matter is in potency, first of all, to the form of an element. When it is existing under the form of an element it is in potency to the form of a mixed body; that is why the elements are matter for the mixed body. Considered under the form of a mixed body, it is in potency to a vegetative soul, for this sort of soul is the act of a body. In turn, the vegetative soul is in potency to a sensitive soul, and a sensitive one to an intellectual one. This the process of generation shows; at the start of generation there is the embryo living with plant life, later with animal life, and finally with human life. After this last type of form, no later and more noble form is found in the order of generable and corruptible things. Therefore, the ultimate end of the whole process of generation is the human soul, and matter tends toward it as toward an ultimate form. So, elements exist for the sake of mixed bodies; these latter exist for the sake of living bodies, among which plants exist for animals, and animals for men. Therefore, man is the end of the whole order of generation.

"And since a thing is generated and preserved in being by the same reality, there is also an order in the preservation of things, which parallels the foregoing order of generation. Thus we see that mixed bodies are sustained by the appropriate qualities of the elements; plants, in turn, are nourished by mixed bodies; animals get their jrourishment from plants: so, those that are more perfect and more powerful from those that are more imperfect and weaker. In fact, man uses all kinds of things for his own advantage: some for food, others for clothing. That is why he was created nude by nature, since he is able to make clothes for himself from other things; just as nature also provided him with no appropriate nourishment, except milk, because he can obtain food for himself from a variety of things. Other things he uses for transportation, since we find man the inferior of many animals in quickness of movement, and in the strength to do work; other animals being provided, as it were, for his assistance. And, in addition to this, man uses all sense objects for the perfection of intellectual knowledge. Hence it is said of man in the Psalms (8:8) in a statement directed to God: "Thou hast subjected all things under his feet." And Aristotle says, in the Politics I, that man has natural dominion over all animals.

"So, if the motion of the heavens is ordered to generation, and if the whole of generation is ordered to man as a last end within this genus, it is clear that the end of celestial motion is ordered to man, as to an ultimate end in the genus of generable and mobile beings."

St. Thomas Aquinas, Summa contra *Gentiles*[37]

NOTES TO CHAPTER XII

1. On *Truth,* q. 3, a. 1.
2. Summa *Theol.,* I, q. 5, a. 4.
3. On Truth, q. 22, a. 12.
4. Summa *Theol.,* I, q. 5, a. 2, reply 1; Com. on the *Met.,* Bk. V, les. 2, nn. 771, 775; *Exposition of the Post.* Anal., Bk. II, les. 8, n. 481; Com. on *the Met.,* Bk. V, les. 3, n. 782; On Truth, q. 28, a. 7; Sum. cont. Gent., Bk. II, ch. 17.
5. On Truth, q. 28, a. 7.
6. Com. on On Gen., Bk. I, les. 20.
7. On Truth, q. 22, a. 2.
8. Com. on the *Met.,* Bk. I, les. 4, n. 71.
9. Com. on the *Phys.,* Bk. II, les. 13, 3; On Truth, q. 22, a. 1; q. 5, a. 2.
10. Cf. J. Weisheipl, "Space and Gravitation," *The New Scholasticism,* XXIX (1955), 186.
11. Cf. supra, Chapter III, pp. 56-57.
12. Aristotle, On Generation and Corruption, II, 10, 336a, 27-28.
13. Phys., Bk. II, ch. 9, 199b, 34-35; *Prin.* of Nat., 33; Com. on the Phys., Bk. II, les. 15, 2; Sum. cont. Gent., Bk. II, chs. 29-30; Bk. I, chs. 83, 85; On *Truth,* q. 17, a. 3.
14. Ibid.
15. Phys., Bk. II, ch. 9, 200a, 12-13; Com. on the Phys., Bk. II, les. 15, 4.
16. *Ibid.,* les. 15, 5.
17. Com. on the Met., Bk. VII, les. 6, n. 1392.
18. Sum. cont. Gent., Bk. Ill, ch. 74.
19. Com. on *the Eth.,* Bk. I, n. 31.
20. Summa *Theol.,* I, q. 2, a. 3; Sum. cont. Gent., Bk. Ill, ch. 18; Bk. II, ch. 78.
21. On the Power of God, q. 3, a. 6, reply 26; *ibid.,* a. 18, reply 5; Aristotle, Politics, Bk. I, ch. 15. St. Thomas thinks that the entire transformation of mundane bodies is in some way ordered to the multiplication of souls; cf. On the Power of God, q. 3, a. 10, reply 4; On Truth, q. 14, a. 5.

22. Com. on On Sense, ch. I.
23. Cf. L. Dufault, "The Philosophical and Biological Implications of Evolution," Proceeding of the American Catholic *Philosophical Association,* XXVI (1952), 66-80.
24. On the Power of God, q. 4, aa. 1 and 2.
25. We have considered, in Chapter X, Darwin's hypothesis of slow accidental variations which is one of his principles of evolution (cf. p. 204), and we can consider this context as an assessment of his other principle, the struggle for existence; cf. infra., p. 250.
26. On the Power of God, q. 5, a. 4, reply 2; Sum. cont. Gent., Bk. III, ch. 71.
27. *Ibid.,* q. 5, a. 7, reply 9; a. 9.
28. Sum. cont. Gent., Bk. II, ch. 46.
29. On Truth, q. 2, a. 2.
30. Com, on On the Soul, Bk. II, les. 1.
31. The intrinsic end of the study of nature is to consider the soul of man. Com. on the Phys., Bk. II, les. 4, 10.
32. Summa *Theol.,* I, q. 91, a. 3.
33. Sum. *cont. Gent.,* Bk. III, ch. 112.
34. This is why the so-called irascible appetites, having to do with struggle, are subordinate to the concupiscible appetites. Summa Theol., I–II, q. 25, a. 1.
35. This argument was suggested by W. James's Human Immortality (Boston, 1898), pp. 40-41.
36. On the Power of God, q. 5, a. 5.
37. Bk. III, ch. 22. Translated under the title On the Truth of Catholic Faith, transi. V. Bourke (New York, 1956), Bk. III, P. I, pp. 86-87. Reprinted with permission of Doubleday and Company.

CHAPTER XIII

MOTION DEFINED

I. THE RELEVANCE OF DEFINING MOTION

a. *Motion Is the Common Predicate in Our Science*

In a perfect demonstration — the mode of argumentation proper to any scientific inquiry — a property is predicated of a subject by means of a principle,[1] and every science is possible only to the extent that there are first principles in that science. Now we have already established that **a science of mobile being is possible because there are first principles in the physical world,** using the reasons advanced by Aristotle in Book I of his *Physics.* These principles make demonstration possible. Demonstration, in turn, involves three things: the subject, the middle term, and the property. As we have already shown, and as Aristotle showed **in Book II of his** *Physics,* **the subject of the science of nature is whatever comes to be by nature; and the middle terms for demonstrations about that subject are the four causes: matter, form, agent, and end.**[2]

The third item in the demonstrations of our science has not yet been identified. That item is the property of mobile being, namely motion itself, and our present chapter, paralleling Book III of the *Physics,* is devoted to a consideration of this property. In the following chapter, a characteristic that follows intrinsically upon motion, namely the infinite, will be discussed. After an analysis of motion considered in its intrinsic character, attention will then turn to place and time, the extrinsic measures of motion which are treated in Book IV of Aristotle's *Physics.*

The reason why motion claims our attention before all other "attributes" in the physical world is that it is the most striking characteristic of sensible things. Motion is involved in the very definition of nature; whoever ignores motion ignores nature itself.[3]

b. Two *Divisions Leading to Our Definition of Motion*

Following the natural direction of the human intellect, our definition is going to focus upon motion in general rather than upon this or that particular kind of motion. And as division is the way to definition, it will be instructive to approach our definition of motion through a division.

There are two principal divisions of the things we experience. On the one hand, the things we experience can be divided according as they are actual or potential; and on the other hand they can be divided into the ten categories, namely substance and its nine accidents.[4] By classifying things as actual or potential, we are dividing them as either in a state of fulfillment and realization or in a state of capacity and possibility. Every seed, for example, is potentially an adult plant; actually, however, it is only a seed. Potency thus means mere ability or aptitude; it means possibility. Act is a realization of this possibility.

Divided into the ten categories, a reality is either a substance or one of the nine accidents: the quantified, the qualified, the related, when, where, being situated, being equipped (clothed), to act, and to receive. Motion takes place in several of the categories, as our later discussion will bring out; there is motion according to quantity, as when a thing becomes bigger or smaller; motion according to quality, as when there is a change of color; and motion according to place, as when a thing moves from here to there. In a wider sense, there is motion also in the category of substance, as in substantial change.

The division of realities into the ten categories is not a subdivision of the previous division into act and potency. For act and potency occur in all the categories. What is potentially a substance and what is actually a substance belong in some way to the same category; the potentially red belongs, like the actually red, to the predicament of the qualified. Since act and potency appear in all the categories, the categories cannot be a subdivision of the division of reality according to act and potency. To divide matter according to the predicaments on the one hand and on the other hand according to act and potency is merely to divide the very same thing according to two different principles of division. Both divisions of reality are necessary in order to understand the definition of motion and the relation of motion to being. Both divisions involve subjects that we already know, since the categories have been studied in logic and since act and potency are the same as form and matter in the science of nature.

II. MOTION AND THE TWO DIVISIONS

a. *A Faulty Definition*

There is always a temptation to define motion as some kind of passage from act to potency or possibly even as the actualization of the potential. But such apparently easy definitions beg the question.[5] For passage is itself a case of motion; actualization also designates a process of some sort. To define motion as a passage or a process would be simply to say that motion is motion, and such a definition would be a circular one.

In this context let us listen to the definition of motion in Descartes:[6] "motion . . . is the transference of one part of matter or one body from the vicinity *of* those bodies that are in immediate contact with it, and which we regard as in repose, into the vicinity of others." The use of the term transference makes the Cartesian definition beg the question; for like passage or actualization, transference is a case of what we are trying to define. There are many examples of definitions of motion which beg the question.

b. *Potency and Act as "Modes"*

In approaching our own definition, let us recall from our division that there are two states in which a being may be. It may be actual, as the mature oak is actually an oak tree; or it may be potential, as an oak tree exists potentially in the acorn. Water vapor in the form of a cloud is potentially on the ground; later on, after rainfall, it will be actually there. Potency and act may be regarded for the present as each constituting a status or a "condition" or "mode"[7] of being; a being may be in an actual status or in a potential status. For a being to be in act does not add anything to its content; as Immanuel Kant remarked, there are no more pennies in an actual dollar than in a possible one. Potency and act divide being according to "condition," or "mode," whereas the categories divide being according to content. Tire possible dollar is in a potential mode; or, more accurately put, my possession of a dollar as yet unearned is potential. When possessed, the dollar will be mine actually and not merely potentially. Considered only in a context *of* act and potency, a raindrop potentially on the ground and one that is actually there do not differ in their constitution and in their relation to the ground. But the first is in a mode of capacity and the second has this capacity fulfilled.

c. A *Third "Mode": Imperfect Act*

In addition to being in act and being in potency, there is a kind of third mode which a being may have.[8] This mode or condition is that of motion. **Motion is a kind of medium between act and potency,** so that a thing in motion is neither in one state nor in another but somehow in between them. A thing that has not yet been moved is in a mode of potency; a thing whose motion is over is in the mode of act; in our third mode, that of motion, a thing is "partly" in potency and "partly" in act. An apple growing red is no longer in mere potency to be red because it has something of red already; but neither is it in full act, because it will become still redder as the ripening goes on. In relation to red, such an apple is neither in pure potency nor in full act but somehow in between. A substance being heated is no longer in simple potency to be heated but neither is it actually as hot as it will be when the heating is complete. To be growing red or growing hot is thus somehow to be in the middle ground between being in act and being in potency with respect to the terms of a given motion. This is why motion has been placed among the indeterminates;[9] a thing in motion is neither this nor that — neither fully red nor absolutely non-red, neither hot nor cold. Since motion involves the indeterminate, it is extremely difficult for the human mind to grasp motion.

From our two examples, that of the apple growing red and of a substance growing hot, motion can be seen at once to be some sort of imperfect act.[10] What is reddening is in some way red but not perfectly so; what is being heated possesses heat but in an imperfect manner when compared to **the term of the process.** Imperfect act is act which involves an order to a further act. If in this imperfect act, e.g., being heated, we consider only the act, we are regarding a given motion to the extent that it is already terminated, whereas if we advert to the imperfection we are considering the motion as unterminated and as having further potency. In the case of local motion, if we consider only what is actual we are referring to something achieved and ended and no longer potential, whereas if we consider only the trajectory yet to come as opposed to what has already been completed we are considering a motion according to what is unachieved, unended, and hence imperfect. In contrast to potency, motion is act; in contrast to full act, motion makes reference to unfulfilled potency.[11] Motion is thus an imperfect reality, a mode of being partly in act and partly in potency.

d. *Motion and the Categories*

With this background, we can now say how motion is related to the categories. What is actually red is clearly in the category of the qualified; and what is actually large belongs to the category of the quantified. Now what is growing red or growing large is reducible to the category toward which it tends, as the imperfect is reducible to the perfect.[12] A baby is called a man, even though it is not yet in all respects a man; and reddening is reducible to the category of the qualified and growth to the quantified in similar fashions. As will be later seen, not all of the categories involve motion;[13] but wherever motion does occur, it is said to be reducible to that category in which it is taking place as an imperfect reality is reducible to the perfect.

It is clear at any rate that motion is not something only in act or something only in potency. What is in act has already been moved and what is in potency has not yet been moved at all.[14]

III. THE FIRST DEFINITION OF MOTION

a. *Motion as Act*

Motion is the act of what exists in potency precisely insofar as it exists in potency.[15] In Aristotle's words, "The fulfillment of what exists potentially in so far as it exists potentially, is motion."[16] As in the case of other definitions throughout the general science of nature, the foregoing definition is a nominal one. It states what is meant by the term **motion.**[17] But like all definitions that are not merely arbitrary and artificial, our nominal definition of motion must be explained and **defended. It** claims to represent what men think about when they refer to motion, i.e., what they mean when they use the term or some synonym corresponding to it. Our definition claims that motion is the act of the potential as potential or the fulfillment of a capacity precisely as capacity. The three parts of the definition must be exemplified and explained: motion is act; it is the act of the potential; it is the act of **the potential as potential.**

What is undergoing motion was previously in a state of potency but, since it is in motion, is no longer in that previous state; it is therefore in the state of act or, put more simply, it is an act. An apple that is growing red is no longer merely in potency to be red, and a leaf that

is falling earthward is no longer in the same previous state of sheer potency. What was in potency but is no longer so must somehow be in the condition of act.

What was previously in a potential condition within our mobile world had a potency to two acts:[18]

The first is a perfect act, as when our apple is as red as it will be or when the leaf is actually on the ground. In the case of a house, there is a potency in the material for the house to be completely made into a house.

There is also another kind of act to which things are in potency and which the kind of act just mentioned really presupposes: this is an imperfect act which is motion; and in this status we find such things as the reddening apple, the falling leaf, the house under construction, the water being heated. Here the things undergoing change are not yet in perfect act because in perfect act there is a term to motion and, where there is perfect act, motion is complete. But our reddening apple, our falling leaf, our water being boiled, and our house a-building are not in perfect act. The state they are in, as opposed to perfect act, is imperfect act. This is motion.

Corresponding to the distinction between perfect act and imperfect act is a twofold potency: a potency to become and a potency to be. An apple that is green has a potency to become red and also a potency to be red. Materials have a potency to become a house and also a potency to be a house. The act of the first kind of potency in both of these examples is motion; the act of the second kind of potency is the term of motion.

Whether the distinction between perfect and imperfect act and the distinction between the two corresponding potencies be admitted or not, this much is clear: Motion is in some way act since what is in motion is no longer merely potential.

b. *Motion Is the Potential*

Motion is the act of the potential. Only what is in potency can be characterized by motion. To the extent that a potency in the physical world is fulfilled the corresponding motion is over. Thus, the materials in a house already built cannot undergo the motion involved in the building of that house; they may, and obviously do, have potencies to other things besides this house, but precisely as the materials of this house that is already built, their potencies are fulfilled with the com-

pletion of the house itself. In a kindred way, the apple that is as red as it will be has no more potencies to become this color which it already possesses; and motion toward such a color becomes impossible. Only what has potency can be moved, and when this potency is fulfilled, there is no more motion that fulfills it.

c. *Motion Is of the Potential as Such*

The most difficult phase of our definition comes with the addition of as potential. Motion is the act of the potential precisely as potential. This is often put: Motion is the act of the potential qua potential. To identify motion simply as an act and even to characterize it as the act of the potential without adding the last phrase is to speak of motion as already complete and hence to refer to the term of the motion rather than the motion itself. In the case of a house, the act of the buildable, i.e., the act of the potential, is not the process of being built but the term of the process; the act of the buildable is the built house, not its process of construction. Hence, our definition in its third part refers to the fact that the motion being defined is not at its term and is not complete but is more or less distant from its term, therefore still under way.[19] Why does this third part of our definition mean that the motion is still going on?

In another dialectical model, bronze is in potency and also in act but not in the same way. It is actually bronze; it is potentially a statue. Now the motion that the bronze undergoes when being shaped into a statue is the act of the bronze, not insofar as it is bronze — for such an act is the reality of bronze itself and not a statue — but insofar as it has a potency to something else, the figure given it by the sculptor. If we said in our present context that motion is the act of the potential we would be designating the bronze; but when we add that our motion under consideration is the act of the potential insofar as there is a potency (to something else), we are signifying that motion is going on and that the term or perfect act of the process has not yet been achieved. It is not the same thing to say bronze on the one hand and on the other potency to be a statue.[20] They are different in a significant way. The making of a statue is not the act of the bronze for such an act makes bronze what it is as bronze — but the making of a statue is the act of a potency that, unlike the bronze, is not yet in act. The motion, i.e., the becoming of a statue, is the act of the bronze not insofar as it is bronze — for as bronze it is already made or moved to be bronze — but

insofar as it is in potency to be a statue. The act of the potential taken alone without our third phrase could be either bronze or the completed statue, either the state previous to motion or the state after it, depending on our viewpoint. The act of the potential only insofar as it is still in potency to be a statue is the motion we are trying to characterize.

The act of the potential precisely as potential is motion. This is our nominal definition and it correctly expresses what we mean when we think or use the term motion. Previous to any act there is only potency; after potency is fulfilled there is only act. A thing in motion, therefore, is moved neither before nor after it is the act of the potential precisely as potential.

Thus, although our language finds it awkward to get many words like buildable as contrasted with built, the heating of water is the act of the heatable qua heatable; the bleaching of wood is the act of the bleachable qua bleachable. The growth of a cat is the act of the enlargeable qua enlargeable. If we said qua hot, qua bleached, qua enlarged or grown, we would be designating no longer a process but its term.

A thing in motion is always other than it was, and the third part of our definition brings out this fact. A thing that has changed is also other than it was but the change is over and this is not the otherness connected with motion. There is otherness as in the case of a man who has moved from one place to another; at the end of his motion, he is other than he was. But this is not otherness as expressing motion itself. Rather it is otherness at the end of a motion by comparison to a motion before it began. At neither end is there motion.

As the act of the potential qua potential, motion is the act of the potency for otherness. As act, it is more than just the previous state where only a potency for otherness existed; as potency, motion is less than the final state where the otherness has been achieved. Motion is the act of something only insofar as it has a potency for otherness, and so our definition expresses the fact that a thing in motion is not just potentially other nor actually other but is being made other by the fact that its potency for otherness is actualized. Because of this tendency to otherness, motion seems to be a special kind of relation.[21] But this point need not be further examined in an introductory book.

Motion is the most imperfect kind of act. It is fitting that such an act should be the instrument for all our natural knowledge. The most imperfect kind of act forms an object proportioned to the most imperfect level of intelligence.

IV. THE SECOND DEFINITION OF MOTION

a. Our *First Demonstration*

After the definition of motion, the inquiry can turn to the subject of motion. Is motion in the agent or in the thing moved by the agent, or is it in some way in both? The answer to this kind of question *will* enable us to identify mobile being more precisely, for it will enable us to know the subject in which motion takes place.[22] Our search to answer our question will bring us to the first perfect (propter quid) demonstration in the general science of nature. Tin's demonstrative syllogism should be stated right away:

The act of the potential precisely as potential is the act of the mobile precisely as mobile.

But motion is the act of the potential precisely as potential.

Therefore, motion is the act of the mobile precisely as mobile.

In order to penetrate this argument, it is first of all necessary to understand what is being said. Our conclusion actually contains another definition of motion, a so-called material definition.[23] It shows what the subject of motion is. It states that motion is in the mobile, i.e., in the thing capable of being moved. The mobile is here being contrasted with the mover or agent.

The distinction between the mover or agent on the one hand and the thing capable of being moved by that agent on the other will be a crucial one in the following discussion.

b. *Objection: Motion Is in the Mover*

Yet contrary to our conclusion there are initial indications that motion goes on in the mover or agent as well as in the thing capable of being moved by that agent. For one thing, every natural mover is in a state **of potency to be a mover, and in this respect, it must be moved to perform as an agent by another agent outside itself.** The hammer as a mover will drive a nail only when the hammer is moved by the hand of the carpenter; it would therefore look as though motion is not only in what receives the motion, i.e., in the nail, but also in what communicates the motion, i.e., in the hammer. Moreover, since natural motion occurs by contact between the mover and thing moved and since **the thing moved always reacts in some way upon the mover, it would look again as though the mover itself undergoes motion. The saw that**

cuts wood is dulled by the cutting, and even though it is a mover, it would thus seem to be moved or changed.

Unless both of these difficulties can be resolved, there is no need of trying to show that motion, as such, is not in the mover but in the mobile, i.e., in the thing capable of being moved.

c. *Motion is in the Mobile*

Concerning our first objection, it can be argued that to the extent that a mover, e.g., the hammer, is moved by something else, e.g., the hand, the mover is not precisely a mover but a being that is moved; therefore it can still be true then that as a mover the hammer is not properly said to be moved.[24] Concerning the second objection, that the thing acted upon reacts upon the agent, it can be proposed that precisely as acted upon rather than as acting, the "agent," e.g., the saw that is dulled, is not truly an agent but a "receiver."[25] Tire two objections, then, do not destroy the truth of the conclusion that motion is the act not of the mover but of the mobile, i.e., the thing capable of being moved.

The truth of this conclusion follows at once from the truth of the premises in our demonstration. Since the minor has already been established in connection with our first definition of motion, it remains now only to establish the truth of the major proposition, i.e., the act of the potential as potential is the act of the mobile as mobile. The proof of the major is that such an act, i.e., the act of the potential as potential, cannot be the act of the mover for the reason that the causing of motion must be the act of something actual, not the act of something potential.[20] The potential as such cannot operate; a potential storm can never cause any damage or do any good. It simply cannot operate as a cause. Only what is actual can cause. As actual, then, the agent does not undergo the act of the potential as potential — although as moved by some other cause, as a receiver rather than an agent, the "agent" may be potential. The only other possible subject of motion is the mobile. As the act of what exists in potency, motion takes place only in the mobile; motion is in mobile being and what goes on in the producer of the motion cannot properly be said to be motion.

How then shall we characterize the act of the mover?

V. ACTION AND PASSION

a. One *Motion: Two Relations*

Analysis of experience will show that it is the same motion which in different ways characterizes both the agent and the receiver.[27] Thus the impressing of a seal on wax is not two motions, one in the seal and the other in the wax. Rather it is one motion impressed by the seal **on** the wax.[28] Tire seal is impressing something on the wax to the precise extent that the wax is receiving the impression; and the wax is receiving the impression just to the extent that the impression is coming from (or rather by) the seal. Thus there are not two motions here but only one; it is by the seal but on or in the wax. In generalizing the principle in question, it may be said that motion is by the mover as by an agent cause;[29] but it is in the mobile as in a receiver or material cause or "patient."

It is important here to tighten up our terminology even more. The agent is the principle from which or by which **(terminus a quo)** motion originates, and motion considered in reference to the principle from which it comes is called action. However, it is extremely important to distinguish between the "principle from which" **(terminus a quo)** of motion and the "principle out of which" **(terminus ex quo). The principle out of which (terminus** ex **quo)** motion comes is the patient, **not** the agent. (Let us remember from our discussions of the efficient cause the notion of emergence or evolution when something new comes **about in** our world; one thing comes **out of** something else rather than is **put into** something else.) Motion really comes out *of* the patient. Nothing ever goes out of the agent into the patient. Motion rather comes forth from the patient under the causality of the agent. Motion in this light is **out of** the patient and **by** the agent. As the efficient cause, the agent remains extrinsic to motion. The patient, or receiver, is the material cause **out of which** motion originates and **in which** motion remains. In summary, **the** patient is that **out of which (terminus ex quo) and in which (terminus in quo)** motion occurs, while the agent is that **by which (terminus a quo)** motion takes place. Action and passion, like the impressing by the seal and the impressing on the wax, are not two motions but one. As by the agent it is action, and as in or from or out of the patient it is passion.[30]

In terms of our first definition, motion is defined as the act of both the agent and the patient but as the act of each in a different way.[31]

The difference between motion as characteristic of agent on the one hand and of the patient on the other is stated in the second definition. That is why the second definition is important. For this second definition reveals that the reality in which motion takes place, i.e., the subject of motion, is the mobile, the thing capable of being moved. While characteristic of the mover also, motion is by it. It is in and really out of (ter**minus ex quo**) the mobile. Imperfect act, like perfect act, is an emergent from the material cause, because nothing really passes to or into the patient from the agent.

A thing can be one in several ways: First there is oneness in both being and relation,[32] and an example of this would be shoes and leather foot-coverings which are truly identical with each other. A second way of being one is according to being but not according to relation, as the motion of the agent in relation to the motion of the receiver. Motion is here truly one in being but different in relation. It is by the agent; it is in the patient. Motion is **in** the receiver as an effect.

b. *Motion Is by the Agent and in the Patient*

There are many examples to show where things may be one in being but twofold in their relations. Buying and selling, for instance, are one transaction; nothing is bought unless something is sold and vice versa. The item exchanged is the very same thing for both parties. But to the extent that there has been a transaction accomplished at all, the item is by the possessions of the seller and in or to the causality of the buyer.

A similar instance is teaching and learning. The same knowledge is involved at both ends of the process; but it is by the teacher but in and **out of** (the very meaning of education is an educing) the learner. In a fashion similar to motion, the ascent and descent of a mountain road are the same stretch of space. But there are different relations at each end of the trajectory as our language — "up" and "down" — reminds us.

It is interesting to consider the implications of action and passion in a series of causes where one thing moves another until some final effect is produced. Let us consider the case where our hand moves a hammer and the hammer drives a nail. In order for this process to go on, other causes will be operating and other effects will be produced. But in order to simplify our consideration, let us consider only these three processes.

that of the hammer, that of the hand, and that of the nail. In such an isolated series of causes, the hammer is a moved mover; as moved, it has its own potencies reduced to act and as a mover it is the instrument by which there is a similar eduction in the potencies of the nail. But it is surely not the same something that is received from a cause by a moved mover and communicated by such a mover to the effect. Motion in the hand, the hammer, and the nail is not something like a baseball passed from one player to another; it is not like a package which is now here and now there as it proceeds from a counter to a shipping department and finally to the address where it is delivered. In reference to our example, according as motion by the hand is motion brought forth out of the hammer, the hammer is a receiver or patient; but according as the hammer in turn acts upon the nail, the hammer is an agent. Tire hand actuates the passive potencies of the hammer whose active potencies then actuate the passive potencies of the nail.[33] But the motion is not mechanically passed along. Tire hammer contributes something original in the process; it does not merely relay to the nail the motion received from the hand; if that were so, the bare hand could drive the nail as well as the hand assisted by the hammer. Something happens in between the causal motion of the hand and the effected motion in the nail. This original something comes from the very natural substances out of which the hammer is made; for, as we said earlier, natures when acted upon do not react in a merely formless and purely passive way. They contribute something of their own to the effect.

Motion is one. As by (a quo) the agent, it is action; as in or out of (ex quo) the recipient, it **is passion.** But this insistence on the unity of motion in the cause and the effect does not affirm an absolute unity between action and passion. They are the same motion with differing relations. Action and passion are each motion but motion as relating to its active cause on the one hand and to its receiving subject on the other.[34]

To discuss motion as such abstracts from whether we are discussing action or passion. It is only when something else is added to the concept of motion that action and passion are seen to be different. When this something else that is added to motion is the relation of the agent to motion, we are considering action; and when this something else that is added to motion is the relation of the recipient to motion, we are considering passion.

c. Motion *and the Categories*

Motion is related to the categories in a twofold way.[35] To the categories in which it takes place, e.g., the quantified, the qualified, where, motion is reducible as the imperfect is reducible to the perfect. This point has already been seen. In the second place, motion is related to the categories of to act and to receive. To act is to move as by the agent; to receive is to be moved as in the subject or patient.[30]

VS. MOTION AND THE SUBJECT OF OUR SCIENCE

a. Motion and Our Intellect

Our first definition of motion has enabled us to reach a demonstrated conclusion concerning the proper subject of motion. **It is with motion as in the mobile being, i.e., with the most imperfect of all acts, that the human intellect, the most imperfect of all intelligences begins its quest for truth.** From such an imperfect act, everything else, including the act of the agent, is known. Anything less than such an imperfect act would be merely potential and hence unknowable; anything more would plunge us into a knowledge whose presupposition we had not duly examined. Motion as such is knowable to us only because of the element of act which it contains and which our definition records in its very first part.

Knowledge is possible to the extent that there is in the mind a certain kind of unification or organization. But potency as such is disunified, plural, indeterminate, at any rate unorganized. This may be shown by simply observing that what is in potency can be actualized in a number of ways (i.e., is plural) depending on the character of the agent acting upon it;[37] snow that is in potency to be melted can be dissolved in a number of ways depending on the heat of the water that is applied and on the points of application. Potency says plurality or indetermination; and because knowledge requires unity or determination, potency resists our efforts to know it. When in act, a thing is definitely and determinately this or that; it is in terms of act that things are knowable to us.

b. *Motion: Demonstration and Observation*

Motion, it was remarked, should be classed in some way among the

indeterminates; a thing in motion is neither this nor that. Yet whatever is in motion does have a minimal amount of act or determination. It is at one remove from the potential; and it is this imperfect act which makes mobile being — and everything else in the whole reach of our intelligence — intelligible.

We have seen a connection now between the definition of motion and the subject of our science. As a property of a subject and as demonstrated of its proper subject by a middle term, motion has been shown to exist in the mobile because motion is the act of the potential or subjective precisely as potential or subjective. Such is the first demonstration in our science of nature. It reveals to us that motion, observed by induction to be going on in mobile being, must necessarily exist in such mobile being rather than in the mover. **Our demonstration has therefore shown us the proper cause or reason why motion must (de *jure*) exist in that subject where it is (de facto) observed to exist.**

c. *Terminology*

In order to make our first definition of motion and to demonstrate our second, an application has been made of our first principles of nature, namely matter and form. To a student of nature, matter is another way of saying the potential, and form is another way of saying act. Matter is the only kind of passive potency that can be found in the physical world by our science of nature; and form is the only kind of act that this science can grasp. In natural theology, another kind of act and another kind of potency are discovered to exist;[38] but throughout the remainder of this treatise, matter and potency can be considered as synonyms and so also can form and act.

In the mobile world, action is what characterizes a mover, and passion, the thing moved. In order to avoid misunderstandings that frequently occur in the minds of beginners, it may be appropriate to remark that not every action involves motion.[39] The activities of the human intellect and will, for instance, and even the operations of our senses and our sense appetites are cases of action or operation: but in the proper sense of the word, they cannot be called motion. According to our analysis so far, motion always involves a privation or loss of some kind. In a thing moved, the old form is lost to the extent that a new one is acquired. But for their proper operations human knowledge and will do not involve privation.[40] No old knowledge is lost when new knowledge is acquired; indeed, the old knowledge is not only retained

but strengthened. In a similar fashion, acts of virtue do not entail privation or loss but on the contrary are a gain in strengthening what already exists. Acts of thinking and willing are perfect acts.[41]

Our definition of motion and our discussion of action and passion are useful to the remaining parts of our science of nature. If everything in the universe involves motion, it is proper that motion should be defined first.

VII. SUMMARY AND CONCLUSION

It is necessary to define motion at the very beginning of a science of mobile being. In approaching our definition, motion requires the division of being into act and potency and into the categories. In this light, motion is an imperfect act and is related to the category in which it occurs. Motion is the act of the potential precisely as potential. It is the act of the mobile insofar as it is mobile. As by an agent, motion is action; as out of or in a patient, motion is passion or reception. Motion is thus the act of the agent or the patient, of the agent as by it and of the patient as **in** it.

REVIEW QUESTIONS

1. Why is it proper to define motion at this point in our science?
2. What two divisions of being are needed to define motion? Why?
3. How does motion relate to act and potency? to the categories?
4. What is the first definition of motion?
5. Explain this definition.
6. What is meant by saying that what is potential may have a twofold potency?
7. Why is it so important to add the third part of our definition?
8. Explain the first definition of motion by comparison to the making of a statue.
9. State the second definition of motion.
10. Prove this definition.
11. What possible evidences are there that motion is in the mover?
12. Why are such evidences rejected?
13. Explain the relation between action, passion, and motion.
14. What is the relation between motion and human knowledge?
15. What is the relation between our second and demonstrated definition of motion and our observation concerning the subject of motion?

PROBLEMS

Explain the following passage:

"He next explains the different parts of the definition. First with regard to motion as 'act/ then 'of the existent in potency/ and thirdly 'in so far as it is in potency.'

"About the first he makes two observations. An act is that by which a subject previously in potency to something, actually becomes that something. But a subject previously in potency is actually becoming while it is being moved. He says it is clear, then, that motion is just that, namely an act. For instance, 'buildable' implies a potency to something. But when in keeping with that implied potency, the buildable is being reduced to act, we then say that it is being built. The fashioning it is receiving is its act. The same holds for all other motions, as teaching, healing, tumbling, dancing, adolescence (growth) and aging (diminution). It is to be noticed that before anything is moved it is in potency to two acts; namely to the perfect act, which is the terminus of the motion; and to the imperfect act which is the motion. Thus water before it begins to be heated is in potency both to being heated and to boiling. But while it is being heated it is being reduced to imperfect act, namely motion; but not yet to the perfect act which is the terminus of the motion; with respect to that it continues in potency.

"Secondly, he explains how motion is 'the act of an existent in potency.' Here is his reasoning. Every act is properly the act of that in which it is always found. Daylight is always found in the atmosphere, and for that reason it is the act of the atmosphere. But motion is always found in some 'existent in potency.' Therefore motion is the act of an existent in potency. To explain the minor premise, he says that in some cases the identical thing is both in potency and in act, though not simultaneously nor in the same respect. Thus a thing is hot in potency and cold in act. So, too, many things act and are acted upon by one another, in the sense that each in its own way is in potency and in act with respect to the other. And since all the sublunary natural bodies have the same sort of matter, therefore in each there is a potency to that which is actual in another. Thus in all such there is something which acts and is acted upon, moves and is moved. For that reason it has seemed to some that absolutely every mover is also being moved. More will be said about that later on. As will be shown in the Eighth Book of this work and in the Twelfth of the Metaphysics, there is a mover which is immobile, because it is not in potency but in act only. When, however, any actual existent, possessed of a potency, is moving either itself or something else, in whatever way it is 'mobile' (that is, capable of being reduced to the act of motion), then, whether it be moved by itself or by another, its motion is its act. Whence it is that things in potency, whether they are acting or being acted upon, are being moved; because in acting they are subject to reaction, in moving

they are being moved. Thus fire when it acts on kindling is reacted upon to the degree of the smokiness of the flame.

"Lastly he explains that clause in the definition of motion which reads 'in so far as it is in potency.' First by an example. He says it was necessary to add 'in so far as it is in potency' because the thing which is in potency is also something in act. And although the existent in potency and in act is the same subject, it is not the same with respect to its being in potency and its being in act. Thus the brass is actually brass and in potency to being a statue, but the reason why it is brass as such is not the same as its potency for the statue. Now the motion (molding) is not the act of the brass as brass, but its act as in potency to the statue; otherwise as long as it remained brass it would have to continue being molded, which is clearly false. So it was correct to add 'in so far as it is in potency.' "

St. Thomas Aquinas, *Commentary on the Physics*[12]

NOTES TO CHAPTER KiII

1. Exposition of the Post. Anal., Bk. I, les. 12, n. 14.
2. *Com.* on the Phys., Bk. III, les. 11 (passim).
3. *Com.* on the Phys., Bk. III, les. 1, n. 539. (Throughout the remainder of the book, the references are to the Angeli-Pirotta edition of the Com. on the Phys.)
4. Phys., Bk. III, ch. 1, 200b, 25-201a, 2; Com. on the Phys., Bk. III, les. 1, n. 548; Com. on the Met., Bk. XI, les. 9, nn. 2289-2292.
5. Com. *on the Phys.,* Bk. III, les. 2, n. 557.
6. *Principles of Philosophy,* XXV, translation cited, I, 266.
7. On the Power of God, q. 3, a. 8, reply 12.
8. On Truth, q. 8, a. 14.
9. Phys., Bk. III, ch. 2, 201b, 28; Com. on the Phys., Bk. III, les. 3, nn. 581, 583; Com. on the Met., Bk. XI, les. 9, nn. 2302-2304.
10. Phys., Bk. III, ch. 2, 201b, 30; Com. on the Phys., Bk. III, les. 2, nn. 560-561; On the Power of God, q. 8, a. 1, reply 9; Com. on the Met., Bk. XI, les. 9, n. 2305.
11. Com. on the Phys., Bk. III, les. 2, n. 560.
12. Ibid., les. 1, n. 552; les. 5, n. 629.
13. Cf. *infra,* Chapter XVII.
14. Com. on the Phys., Bk. III, les. 2, n. 549; Com. on the Met., Bk. XI, les. 9, n. 2294.
15. Com. on *the Phys.,* Bk. III, les. 2, n. 562; Com. on the Met., Bk. XI, les. 9, n. 2294.
16. Phys., Bk. III, ch. 1, 201a, 10-12.
17. For the meaning of a nominal definition not as quid dicitur but as quid est quod *dicitur,* cf. Cajetan, Com. on the Post. Anal. (Quebec, 1950), I, p. 8.
18. Com. on the Phys., Bk. III, les. 2, n. 567.
19. Sum. cont. Gent., Bk. III, ch. 23; On Truth, q. 5, a. 5; Com. on *the Met.,* Bk. XI, les. 9, nn. 2296-2297.
20. *Phys.,* Bk. III, ch. 1, 201a, 30-33; Com. on the Phys., Bk. III, les. 2, n. 572.
21. Com. on the Phys., Bk. III, les. 1, n. 548.
22. *Disputed* Question: On *The Soul,* transi. J. Rowan, a. 1, reply 15.
23. Com. on the Phys., Bk. III, les. 4, n. 585. For the meaning of material and formal definition, cf. my "Definitions" in From an Abundant Spring, "The Walter Farrell Memorial Volume of The Thomist" (New York, 1952), p. 345.
24. Com. on the Phys., Bk. III, les. 3, n. 587.
25. Ibid., nn. 588-589.
26. Ibid., n. 593; Sum. cont. Gent., Bk. III, chs. 23, 69.
27. Phys., Bk. III, ch. 3; 202a, 18-20; Com. on the Phys., Bk. III, les. 5, n. 608.

28. Cf. the excellent study of J. McWilliams, "Action Does Not Change the Agent," in *Philosophical Studies in Honor oí the* Very *Rev. Ignatius Smith, ed. J.* Ryan (Westminster, Md., 1952), pp. 208-221.
29. Com. on *the Phys.,* Bk. III, les. 4, nn. 597-599; les. 5 (passim); *Exposition of the Post. Anal.,* Bk. II, 10, n. 505.
30. Com. on the *Met.,* Bk. XI, les. 9, nn. 2312-2313; Sum. cont. Gent., Bk. III, ch. 16.
31. Com. on the Eth., Bk. IX, les. 7, n. 1846; Com. on *the Phys.,* Bk. III, les. 5, n. 620.
32. Com. on the Phys., Bk. III, les. 5, n. 612.
33. Active potency is the power to do something to something, and passive potency, the power to receive something from something; cf., e.g., On *the* Power of God, q. 1, a. 1.
34. *Phys.,* Bk. III, ch. 3, 202b, 19-25; Com. on the Phys., Bk. III, les. 5, n. 620; Com. *on the Met.,* Bk. XI, les. 9, nn. 2309-2313.
35. Com. on the Phys., Bk. III, les. 5, n. 629; *On the Power oi God,* q. 3, a. 3, reply 8.
36. Com. on *the Phys.,* Bk. III, les. 5, n. 631.
37. On Truth, q. 8, a. 10.
38. The reference here is to essence and its act of existing.
39. Creation, for instance, cannot be a motion because it does not come from any pre-existing subject. Summa *Theol.,* I, q. 42, a. 2, reply 2; Sum. conf. Gent., Bk. II, ch. 17.
40. On *Truth,* q. 24, a. 10, reply 2.
41. On *Truth,* q. 28, a. 9, reply II; q. 24, a. 1, reply 14; q. 8, a. 14, reply 3.
42. Bk. III, les. 2, n. 564 ff. Translation by *J.* McWilliams, *Physics and Philosophy* (Washington, 1945), pp. 32-34. I have taken the liberty, with Father McWilliams' kind permission, to put act in the places where his translation reads actuation, thereby making for consistency with terminology throughout the rest of this book.

CHAPTER XIV

MOTION AND THE INFINITE

I. INTRODUCTION

a. *Relevance of Our Problem*

After the definition of motion, the next item for consideration is the problem of the infinite. The infinite is regarded as an intrinsic consequence of motion, for motion, as we observe it with our senses, is a gradual and successive phenomenon. Local motion, the most common form of change, takes place along an extended trajectory whose parts are covered one by one and whose coverage therefore takes time. **Because of this gradual and successive reality which it owns, motion raises the question of the infinite.**[1] **If there are parts between a thing and the term of its motion, are these parts infinite in number? Is a thing in motion composed of an infinity of parts? Does the mobile world as a whole stretch backward and forward in an infinity of duration, and does the universe expand outward into an infinite space?**

Tírese are some of the questions raised when we ask what motion actually implies. If it turns out that motion involves the infinite, it will be unnecessary to inquire about the so-called extrinsic measures of motion, namely space and time;[2] for what is infinite will not be capable of measure. On the other hand, if motion involves the finite only, then it might look as though there will be a smallest fraction of motion, a smallest part of space, and a smallest unit of time. Can such conclusions be accepted?

b. *An Historical Issue*

From the Greeks like Anaxagoras[3] **all the way down to contemporary physicists like Einstein,**[4] **who pictured a universe that was "finite but unbounded," students of nature have raised the problem of whether there is an infinity in our mobile world. Some thinkers have held that**

the universe is infinite, and others have denied any kind of infinity to matter. If there is any doubt whether it belongs to the science of nature to discuss the infinite, such misgivings can be dispelled by a glance at the history of ideas. Others have already raised the problem of whether motion involves the infinite or not, and such a problem must be frankly faced.[5] Until we answer it, there is no use discussing the measures of motion, time and place. In a study like ours, interest in the problem of infinity is physical rather than mathematical. Our question is whether or not there is an infinity in the physical, sensible world, and our answer is merely a reply to the objection by other thinkers that such an infinity exists.

c. *Is Matter Infinite or Finite?*

At first sight, it would look as though material being is infinite. If, to take an example, the surface of a table top contains two halves, it can easily be seen that within each half there are quarters of the original: the quarters in turn also contain parts, and as we keep on dividing the parts, nowhere is there an end to the division.[6] New parts can always be found in any one part, no matter how small. The atom, believed a century ago to be an indivisible unit and hence the smallest kind of particle to be found in matter, has now been divided into a nucleus and the orbital electrons. The nucleus has been subdivided into such particles as protons and neutrons, and the neutron itself can be split. Is the electron or proton or the meson, in its various kinds, an ultimate particle? There seems to be no reason for saying that any of the fundamental particles is indivisible.[7] There is no evidence for saying that there is a smallest possible particle in nature. There is no quantity of matter so small that a smaller one could not exist; and if this is so, the division of matter can go on and on without ever coming to an end.

But if there is evidence for the infinite in the material world, there is likewise an argument for the absolutely finite character of all mobile being.[8] It takes a finite time, for instance, to roll a marble across our table top, but this would seem impossible if the marble had to traverse an infinity of parts in order to reach the other side. Moreover, if the wood in the table top contains an infinity of parts, it would look as though it could occupy nothing less than an infinite space. But both of these conclusions are contrary to experience. If motion always requires both a finite time and a finite space, the trajectory or external extension through which it passes must be finite, and the internal extension of

the mobile being, moving part by part through a finite external extension or a finite trajectory, must be finite also.

II. SOME DISTINCTIONS

a. *Different Kinds of Infinity*

In order to face this problem, several important logical divisions must be introduced. Two of these logical divisions concern different types of infinity,[9] and a third logical division concerns the different manners of splitting matter into its parts.[10]

The infinite is divided first of all into the actual and the potential infinite. The actual infinite is (nominally) defined as that to which there is no limit in perfection.[11] God is infinite in this sense because no perfection whatsoever is lacking to Him. A series of numbers would be actually infinite if it contained all possible numbers and if, as a result, no new number could be added to the series. The universe would be infinite in its extension if it filled all possible space and if, as a result, it could not be increased in size.

In the second place, there is the potential infinite, which is that to which there is always something beyond.[12] It is that to which something can always be added or, from a different viewpoint, that from which something can always be taken away. A familiar example of this kind of infinity is the straight line of Euclidian geometry. However far extended, such a line will always be actually limited in length and hence actually finite; but new parts can always be added to it without end. It will never be the case that there will be a last part of the line to which no further part can be added. Such a line is potentially infinite. The number series is another example of the potentially infinite. There can never be a number so great that a greater number cannot be attained nor a number so small that there cannot be a smaller number.

b. *Distinction Between* Continuum *and Number*

Besides distinguishing the infinite into its potential and actual forms, it is necessary to make another distinction that our preceding paragraph has already suggested. It is important in our present problem to distinguish between discrete quantity like number and continuous quantity like lines, planes, and solids. Number, to begin with, is multitude measured by a unit. Multitude is thus the genus of number, and the specific

difference, determining the genus into this kind of number rather than that, is the final unit of the number in question. Thus the specific difference that determines or measures multitude into, say, the number seven is the final unit in this number. Varying the unit thus varies the species of number?[3] Another unit besides those in seven would make eight. Number is thus multitude or plurality determined by the unit. For obvious reasons, number can be called arithmetical quantity. It is also called discrete quantity since two numbers, unlike two parts of a line which are continuous with another, have a separate or independent existence.

Continuous quantity or magnitude is quantity having position.[14] It is geometrical quantity, the quantity of a line or figure.

In the light of the two distinctions just made, we can investigate whether mobile being is potentially or actually infinite according to either the arithmetical (discrete) or geometrical (continuous) species of quantity or both.

c. *Distinction Between Physical and Mathematical Division*

But before this question can be properly put, another logical distinction will clear the ground for our discussion. It is the distinction between quantitative (mathematical) and physical (natural) division.[13] Quantitative division may take place without changing the character of the thing divided. Thus, one half of a glass of water may be divided from another, while both of the halves remain water. But if you keep on dividing the water, you will eventually come upon a molecule of water that, on being divided, will cause the physical splitting of water into hydrogen and oxygen. It is possible to envision a purely quantitative division of a material substance which would not change the character of that substance. On the other hand, there are certainly divisions, as atom-smashing proves clearly enough, where the physical character of the substance is also changed. For present purposes, our concern is only with the purely quantitative aspects of division and extension. Our question is not whether on being divided this or that substance undergoes a substantial change but whether any material substance can be divided into an infinity of quantitative parts, i.e., whether a glass of water or a wooden surface contains an infinity of parts and whether, no matter what kinds of bodies exist in the physical world, the space of the world is infinite in quantity.

Thus we are not concerned throughout this chapter with the physical

varieties of bodies brought into existence by our division. Our interest is only in quantitative parts and whether any body or all bodies taken together possess an infinity of such parts and whether such an infinity is actual or potential.

III. EXTENSION IS POTENTIALLY INFINITE

a. *Every Line Is Divisible Into Smaller Lines: The Thesis*

Reason can show that matter, by reason of its quantity, is potentially but never actually infinite.[10] In order to approach this problem from the proper angle, let us consider again the division of the surface in our table top; the area obtained by division can always be subdivided into smaller areas. In an even simpler kind of quantity, a line, there can always be a division into smaller lines. In other words, every line obtained by division is always further divisible.

The proof of the foregoing propositions concerning the surface and the line can be achieved by assuming conclusions opposite to the ones we have drawn. Let us suppose, for example, that after our repeated division of a line there will finally come a moment when a given small part of the line can no longer be divided. Such a part would be an indivisible component of the line, and if it exists, then we cannot carry on infinitely our division of the original line. When we would reach this indivisible, the part of the line in question would no longer be capable of further division. The part of the line, in other words, would be simple. It now remains to prove that our conclusion, and hence our supposition, is impossible.

b. *No Line Made of Indivisibles: Proof*

Indivisible or simple remainders can never be obtained no matter how far we choose to carry the division of our line (or any other quantified thing we would be dividing). If indivisibles turned up after the line were divided a given number of times, the line would have to be made up of indivisibles, i.e., of points. But it is impossible that a line be made of points. For points, allegedly obtained by our division of the original line, could never go together again to yield the line. If we tried, for instance, to set together two points, P and Q, so that P on its right side touched Q on its left, the added points would never yield a line, however small. For points, being indivisible, have no right part and

left part. Whenever they would "touch" each other, they would coincide with each other, and no matter how many points were made tangent, they could never yield an extension, never yield more than the original indivisible character of the first point.[17] A line can never be a mere sum of points no matter how numerous the points may be. An indefinitely great number of points added together would only be "stacked" on top of one another without ever spreading out to yield an extension.

If a point is not a component of a line, then the line can never be divided into points. If indivisibles can never be put together to yield the divisible and the extended, then indivisibles can never be encountered simply by dividing an extension. If indivisibles cannot be obtained by dividing a line, then the parts of a line, however small, are always further divisible. A thing that is always in potency to further division is, in this respect, potentially infinite, i.e., it is divisible into a potential infinity. Such an entity, which is always divisible into further divisibles, is called a continuum.[13]

c. *The Same Principles Applied to Surfaces and Solids*

The principles used in our analysis of a line can be applied to other quantified reality. Just as indivisible points can never be obtained by dividing any line, so by the very same principles a surface cannot be divided into indivisible components which would be lines; for lines, indivisible except in one dimension, could never be superimposed on each other to produce the original surface. If lines do not compose a surface, they cannot be obtained by dividing the surface. As a line is divisible only into smaller lines, so a surface is divisible only into smaller surfaces.

By the same principles, too, a solid can never be divided and subdivided until it yields surfaces as its components. Surfaces stacked on top of one another would coincide with each other, without ever stretching out to form a solid. What is unextended in a given dimension, e.g., depth, cannot be added together to produce that dimension.

Lines can never be divided until we finally reach points; surfaces cannot be divided into a number of juxtaposed lines; and solids are not composed of surfaces. If in dividing the line we can never encounter the indivisible, the line must always be divisible; that is to say, a line in its divisibility is potentially infinite. A similar verdict can be reached concerning surfaces: always capable of division but only into smaller surfaces, any surface is potentially infinite. Solids likewise, since they

are divisible only into smaller solids, embody the potentially infinite in the order of division.

d. *Real vs. Imaginary Division*

The point we are making here does not require that we be able to make real divisions in the quantified things we consider. Take a surface, for instance, and divide it into ever smaller surfaces. There will come a time, somewhere in the series of divisions, when the dimensions of the little surfaces will become so small that we can no longer "see them with our naked eye" and will find it impractical to divide them further by our instruments whatever they are. But when real division is no longer practicable in regard to a surface (or a line or solid), imaginary division can begin and we can simply compute the halves, quarters, and other parts of our surface without actually introducing real division as we would do with a saw or an axe. We are concerned in this chapter not with whether we, from our own practical point, can make a real division of the quantified but whether, on the part of the matter itself, there is divisibility, i.e., the potency for division. We are concerned with whether, after real division is no longer feasible, imaginary division can take place. Our argument has led to the conclusion that a line is always divisible into smaller lines,[18] a surface into smaller surfaces, and a solid into smaller solids. In other words, in the order of division, quantified matter is potentially infinite.

IV. NUMBER IS POTENTIALLY INFINITE

Now in the real world the potentially infinite character of continuous or geometrical quantity assures the potentially infinite character of discrete quantity or number. For when geometrical extension is really divided, real number is increased, and when such extension is merged, real number is diminished.[20] This may be illustrated by imagining a single solid, like a tree or an earthworm or an atom of this or that element, divided into two parts. After such a division takes place, there is numerically at least one more thing in the world than there was before. After a stick is broken, there are now at least two sticks where there was only one before. In other words, when continuous quantity is divided, number is increased. If continuous quantity is potentially infinite in the order of division, discrete quantity or number must be potentially infinite in tire order of addition.[21] The number of things in the real

world can be increased without end because the potentially infinite division of continuous quantity can continue, without end, to supply new members to the number of existing things. Where, as the result of dividing one of the things in our sensible world, another unit can always be added to the unities that already exist, the number of physical things is potentially infinite.

So far, then, it has been shown that in the order of division there is a potential infinity characteristic of continuous quantity which is always divisible into what is further divisible. In the order of addition, number is likewise potentially infinite since the division of geometrical quantity constantly yields new units to be added to an already existing sum of things.

V. MATTER IS ACTUALLY FINITE

a. An *Infinite Line Would Be Infinitely Long*

But another half of our problem remains, i.e., the question of the actual infinite. If we admit that the number of quantitative parts in any divisible thing is potentially infinite, why not go all the way and concede that the infinity is actual? If we grant that the number of things in the world is potentially infinite, why not say that such a "number"[22] is actually infinite? These are the two big questions that remain in our brief study of the division of continuous (geometrical) quantity in the physical world and the addition of discrete (arithmetical) quantity or number.

Though potential infinity must be admitted in both continuous and discrete quantity, the actually infinite in both kinds of quantity must be strenuously denied. **Any actual infinity attributed to matter would lead to conclusions contrary to experience. Any line that contained an actual infinity of parts would be infinitely long,**[23] **and to it, no additions could be made.** A surface, infinite in its actual parts, would be infinite in length and breadth; and any one solid that contained an infinity of actual parts would fill all space. None of these conclusions agrees with experience. All of them are therefore false. Hence the supposition which necessitates these conclusions, i.e., that anything material is composed of an infinity of parts, must likewise be false.

b. *All Bodies Would Be Alike*

As another argument in support of our conclusion, if mobile beings

contained an infinity of parts, they would all be of the same size because they would have the same, i.e., infinite, number of parts.[24] This conclusion goes contrary to experience also, and hence the supposition leading to this conclusion, i.e., that matter contains an infinity of parts, must be dismissed.

Continuous or geometrical quantity is certainly divisible into a potential infinity of parts. Nevertheless, the parts obtained by division, no matter how far this division is carried, will never be actually infinite in number for it is always possible to make one more division in any existing part and thus to get one more part than we had previously. In the order of dividing continuous quantity, there is thus a potential infinity but no actual infinity.

c. *Number Not Actually Infinite*

Since the division of continuous quantity increases the number of things that exist in the real world, there can be no actual infinity of number in the real world if the number of parts in any continuous quantity can never be actually infinite. **Discrete quantity cannot be actually infinite if continuous quantity cannot be. By** dividing continuous quantity, new members can be added to the already existing sum of things; hence, the actual infinite in the order of addition can never be attained. In both arithmetical and geometrical quantity, matter involves the potential infinite but excludes the actual infinite.

VI. ACT AND POTENCY: SUMMARY OF OUR SOLUTION

At any moment, any mobile being as it stands in nature is one and undivided. Before being divided into two, a stick is one and undivided. But though actually undivided prior to division, matter, **g.**, the stick, is in potency to division; it is undivided but divisible. After division, what before was actually one and undivided is now actually divided. There are now at least two mobile beings as the result of the division, each of which is actually one and undivided in itself,[25] but each of which, by reason of its quantity, is in potency to further division. To be divisible — a potency — is not the same thing as to be divided — an actual status. **Continuous quantity,** for **instance a line, is always undivided but divisible; and in a corresponding way, the number of tilings in the order of discrete quantity is always actually finite but potentially infinite.**

VH. THE WORLD IS FINITE IN EXTENT

a. *Determination of the World: A Quantitative Argument*

If the number of things is actually finite, the world as a whole must be finite in extent. For no finite number of things taken together could make an infinity. **If one of the bodies in the series of things that form the universe is finite, all other bodies must be finite in extent;26 for any body that was actually infinite would so fill all possible space that no room would be left for anything else. Now if all bodies in the world are finite in extent, their sum must be finite since the finite added together cannot yield infinity.** The same conclusion can be reached by proposing that since the division of a previously undivided body among the sum of existing things can add one more real body to that sum, there is no infinite number of bodies in the universe; if all the bodies are finite in extent and the number of bodies is finite, the universe must be actually finite in extent as well. But just as the series of numbers can always be augmented, so the universe can continually be enlarged into a potential infinity of extended quantity.

The fundamental question in our discussion of infinity concerns the divisions of continuous or geometrical quantity. If such quantity is potentially but never actually infinite, the same thing can be said concerning discrete quantity or number and concerning the size or expanse of the world's magnitude.

b. *Détermination of Goals Implies Determination of the World*

If the universe were infinite, there would be no determinate goals for local motion. Such motion would then be impossible because indeterminate. This is a cogent and strictly physical argument. In an infinite universe there would be no center, no boundary, no privileged position of any sort whatever, whereas in the determination or order which any motion is seen to possess, there must be a principle like a center or boundary or some other privileged point. Without a principle there is no order. In other words, the existence of system in any motion and in the universe of mobile things requires the finite character of that universe. There could be no system in an actually infinite world because system means order, determination, finiteness.

VIII. REMOTE AND PROXIMATE SUBJECT OF INFINITY

The potentially infinite that we have found to exist in mobile being resides there fundamentally because of primary matter.[27] Potential infinity belongs in a radical way to primary matter which always has one form but, considered under its status of privation, is open to an infinity of other forms. God's infinity is an infinity of perfection: no perfection is lacking to His Being.[28] On the other hand, matter's infinity is an imperfection,[29] an infinity not of excess but of privation.

Although the ultimate ground for the potential infinity in nature is primary matter,[30] the proper and proximate subject of the infinite in the material world is the sensible continuum,[31] i.e., the quantified under a sensible form and figure which is actually definite and determinate but always open to increase and decrease according to the very essence of quantity. No continuous quantity in the world of matter is infinitely long, if it is a line; infinitely long and wide if it is a surface; nor infinitely extended in any of its three dimensions if it is a solid. No discrete quantity is actually infinite in number. Finally, the world is actually finite in expanse.

When the infinite is attributed to anything quantified in our science, the infinite is taken to mean that to which no limit has been assigned.[32] Such a quantity can always be either augmented or diminished as the case may be, without ever reaching an actual limit beyond which quantitative increase or decrease is impossible. The potentially infinite is thus the indeterminate or the indefinite.[33] It is that to which no limits are assigned, that to which, if you assign any small value, a still smaller value can always be assigned; that to which, if you assign a large value, a still larger value can always be assigned; that, in other words, to which there is always a beyond.

IX. POSTSCRIPT: ON AN INFINITE TRANSCENDENTAL MULTITUDE

To prove that an infinity of beings (transcendental multitude) is impossible is a metaphysical problem. St. Thomas Aquinas said, near the end of his life, that no one had yet proved that it was impossible for God to create an infinity of this kind, e.g., an infinity of spiritual beings.[34]

We are here not concerned with an infinity of this kind, as the science

of nature is limited to mobile being and does not reach being as such. Ours is a problem not of so-called transcendental or metaphysical multitude but of predicamental multitude and magnitude, i.e., the quantitative infinite. Such a predicamental or quantitative infinite, we have argued, can only be potential in character. Arguments against the actual infinity of predicamental multitude and magnitude are convincingly clear, e.g., the finite character of any quantity, and determinate goal of any motion, and the system we can discover in any part of our universe.

X. SUMMARY AND CONCLUSION

The question concerning motion's infinity follows immediately upon the question concerning the nature of motion. In order to solve this question, it is urgent to distinguish the various kinds of infinity, to differentiate between continuous and discrete quantity, and to set off mathematical from physical division. Extension as such is potentially but never actually infinite in the parts obtained by dividing it, and consequently the number of these parts is potentially but never actually infinite. From a strictly physical point of view, an infinite universe would permit of no determinate goals for any motion. Matter, in short, can never possess an actually infinite character and is hence always finite even in spatial extent. The proper subject of potential infinity is the sensible continuum, but the root of this infinity is primary matter.

REVIEW QUESTIONS

1. Why does it belong to the science of nature to treat infinity?
2. Why is the infinite called an intrinsic consequence of motion?
3. Give some arguments for the finite and for the infinite character of the world.
4. Give (nominal) definitions of the various kinds of infinity.
5. Differentiate between the continuum and number.
6. Distinguish between physical and mathematical division.
7. Show that if a line is not always further divisible it must yield indivisibles upon division.
8. Prove that a line cannot yield indivisibles on division.
9. Apply to a surface and to a solid the conclusions reached regarding the line.
10. Does the notion of divisibility mean that we must always achieve a real division of a thing? Explain.
11. Show that number is potentially infinite.
12. Show that matter is actually finite.
13. Prove that number is actually finite.

14. How does the determination to goals provide a physical argument for the finite character of the universe?
15. Show how the distinction between act and potency enables us to resolve the problem of the infinite.
16. Prove that the world is finite in extent.
17. What are the remote and the proximate subjects of material infinity? Explain.

PROBLEMS

Explain the following passages in the light of the present chapter:

I

"I answer that, It is one thing to be infinite in essence, and another to be infinite in magnitude. For granted that there exists a body which is infinite in magnitude, as fire or air, yet this would not be infinite in essence, because its essence would be terminated in a species by its form, and confined to some individual by matter. And so, assuming from what has preceded that no creature is infinite in essence, it still remains to inquire whether any creature can be infinite in magnitude.

"We must therefore observe that a body, which is a complete magnitude, can be considered in two ways: mathematically, in which case we consider its quantity only; and naturally, in which case we consider its matter and form.

"Now it is manifest that a natural body cannot be actually infinite. For every natural body has some determined substantial form. Therefore, since accidents follow upon the substantial form, it is necessary that determinate accidents should follow upon a determinate form; and among these accidents is quantity. So every natural body has a greater or smaller determinate quantity. Hence it is impossible for a natural body to be infinite. The same appears from movement, because every natural body has some natural movement, whereas an infinite body could not have any natural movement. It cannot have one in a straight line, because nothing moves naturally by such a movement unless it is out of its place; and this could not happen to an infinite body, for it would occupy every place, and thus every place would be indifferently its own place. Neither could it move circularly, since circular motion requires that one part of the body be necessarily transferred to a place which had been occupied by another part, and this could not happen as regards an infinite circular body: for if two lines be drawn from the center, the farther they extend from the center, the farther they are from each other; and therefore, if a body were infinite, the lines would be infinitely distant from each other, and thus one could never occupy the place belonging to the other.

"The same applies to a mathematical body. For if we imagine a mathe-

matical body actually existing, we must imagine it under some form, because nothing is actual except by its form. Hence, since the form of quantity as such is figure, such a body must have some figure. It would therefore be finite, for figure is confined by a term or boundary."

St. Thomas, Summa Theologiae[35]

II

"I answer that, A twofold opinion has obtained on this subject. Some, as Avicenna and Algazel, said that it was impossible for an absolutely infinite multitude to exist actually, but that an accidentally infinite multitude was not impossible. A multitude is said to be infinite absolutely, when an infinite multitude is necessary that something may exist. Now this is impossible, because it would mean that something is dependent on an infinity for its existence; and hence its generation would never be accomplished, because it is impossible to traverse what is infinite.

"A multitude is said to be accidentally infinite when its existence as such is not necessary, but accidental. This can be shown, for example, in the work of an artisan requiring a certain absolute multitude, namely, art in the soul, the movement of the hand, and a hammer; and supposing that such things were infinitely multiplied, the work would never be finished, since it would depend on an infinite number of causes. But the multitude of hammers, which results when one hammer is broken and is replaced by another, is an accidental multitude; for it happens by accident that many hammers are used, and it matters little whether one or two, or many are used, or an infinite number, if the work is carried on for an infinite time. In this way they said that there can be actually an accidentally infinite multitude.

"This, however, is impossible, since every kind of multitude must belong to a species of multitude. Now the species of multitude are to be reckoned by the species of numbers. But no species of number is infinite, for every number is multitude measured by one. Hence it is impossible that there be an actually infinite multitude, either absolutely or accidentally. Furthermore, multitude in the world is created, and everything created is comprehended under some definite intention of the Creator; for no agent acts aimlessly. Therefore it is impossible for an actually infinite multitude to exist, even accidentally.

"But a potentially infinite multitude is possible, because the increase of multitude follows upon the division of a magnitude, since the more a thing is divided, the greater number of things result. Hence, just as the infinite is to be found potentially in the division of the continuous, because we thus approach matter, as was shown above, in the same way the infinite can also be found potentially in the addition of multitude."

St. Thomas, Summa Theologiae[36]

NOTES TO CHAPTER XIV

1. Com. on the Phys., Bk. Ill, les. 1, n. 541; les. 6, n. 633.
2. Ibid., les. 1, n. 543.
3. Cf. Aristotle, Phys., Bk. I, ch. 4, 187a, 22 ff.
4. Cf. for instance A. Wenzl, "Relativity and Critical Realism" in Albert *Einstein: Philosopher-Scientist* (Evanston, Ill., 1949), pp. 594-595.
5. Phys, Bk. Ill, ch. 4, 203a, 1-3; Com. on the *Phys.,* Bk. Ill, les. 6, n. 635.
6. *Phys.,* Bk.' Ill, ch. 4, 203b, 15-25; Com. on the Phys, Bk. Ill, les. 7, n. 660.
7. P. Bridgman, *The Logic of Modern Physics* (New York, 1927), p. 207.
8. Com. on the Phys, Bk. Ill, les. 7, n. 675 ff.
9. For divisions of infinity, cf, for instance, Summa *Theol.,* I, q. 7 (whole question); I, q. 86, a. 2, reply 1; Sum. cont. Gent, Bk. I, ch. 43; On *Truth,* q. 2, a. 9, reply 7; On the Power *of God, q.* 1, a. 2; cf. J. McWilliams, Physics and *Philosophy* (Washington, 1945), pp. 8, 135.
10. Com. on the Phys, Bk. Ill, les. 11, n. 743.
11. Sum. cont. Gent, Bk. I, ch. 43; Bk. Ill, ch. 54; Com. on On the Heavens, Bk. I, les. 29.
12. Com. on the Phys, Bk. Ill, les. 11, n. 743; Com. on the Met, Bk. X, les. 8, n. 2090.
13. Com. on the *Met,* Bk. VIII, les. 3, n. 1725.
14. Com. on the Phys, Bk. IV, les. 17, n. 1105.
15. Ibid, Bk. Ill, les. 12, n. 762; Summa Theol, I, q. 7, a. 3.
16. Phys, Bk. Ill, ch. 6, 206a, 8 ff.; Com. on the Phys, Bk. Ill, les. 11, nn. 749-750.
17. Com. on the *Phys.,* Bk. VI, les. 1, n. 1454; Com. on On the Heavens, Bk. I, les. 18; Com. on On Generation, Bk. I, les. 4.
18. Com. on the *Phys.,* Bk. Ill, les. 1, n, 541.
19. It would be possible to define a line as "that which is divisible in only one dimension." Com. on the Met, Bk. V, les. 8, n. 874. Similar definitions could be formulated for the surface and solid.
20. Com. on *the Phys.,* Bk. Ill, les. 12, n. 761; On *the Power of God,* q. 9, a. 5, reply 8; Summa Theol, I, q. 7, a. 4.
21. For an important difference between these two infinities, despite their likeness, cf. Com. on the Phys, Bk. Ill, les. 10, nn. 735-737.
22. When we speak about infinite number, number is being used in a different sense from that in notes 12 and 13. It would be better to say infinite multitude; cf. Summa Theol, I, q. 7, a. 4. But usage sanctions such terms as infinite number and transfinite number.
23. Summa Theol, I, q. 7, a. 3.
24. Com. on the *Phys.,* Bk. I, les. 9, n. 141.
25. Cf. the definition of quantum in Com. on the Met, Bk. V, les. 14, n. 977.
26. Com. on *the Phys,* Bk. Ill, les. 9, n. 702 ff.
27. Summa *Theol, I,* q. 7, a. 2.
28. Summa cont. Gent, Bk. II, ch. 52.
29. Sum. cont. Gent, Bk. I, ch. 43; Summa Theol, III, q. 10, a. 3, reply 1.
30. Com. on the Phys, Bk. Ill, les. 12, n. 772; Summa Theol, I, q. 7, a. 3, reply 3.
31. Phys, Bk. Ill, ch. 7, 208a, 1; Com. on the Phys, Bk. Ill, les. 12, n. 773; Summa Theol, I, q. 25, a. 2, reply 1.
32. Com. on the *Phys.,* Bk. Ill, les. 12, n. 769; Summa Theol, I, q. 7, a. 3, reply 1.
33. Summa Theol, I, q. 86, a. 2, reply 1; Com. on the Phys, Bk. Ill, les. 11, n. 747.
34. On the Eternity *of the World* (near the end).
35. I, q. 7, a. 3.
36. Ibid, a. 4.

CHAPTER XV

PLACE: THE MEASURE OF MOBILE BEING

I. EVIDENCE THAT THERE IS PLACE

a. *Relevance of the Problem*

Our last chapter left us with the verdict that mobile being is infinite but only in a potential way; actually, all material things are finite. Because they are finite, all material things are measurable, and it is appropriate now to turn to the fundamental measures in the mobile world, place and time. Place is the measure of mobile being,[1] and time, as our next chapter will show, is the measure of motion.

To define place and to discover what kind of reality it has definitely belongs to the general science of nature. If it is not already admitted that a discussion of place pertains to our science, the following two arguments may be offered.

First of all, everything that exists in the mobile world exists somewhere, and what does not exist anywhere is not thought to have physical or material existence.[2] Now if it pertains to the science of nature to probe mobile being and its fundamental or most general characteristics without which it would not be regarded as a physical thing, then it is surely proper to ask in our present context what it is to have a where or to be in place.[3]

As a second argument which makes it appropriate to discuss place, it should be observed that the most common form of motion in the universe is local motion, i.e., change of place, and it would be illogical to attempt a discussion of local motion without having first determined what is meant by location and by place.[4]

b. *Evidence for Place*

The fundamental argument that place exists is a factual demonstration **(demonstratio quia).**[5] From a nominal definition of place that will be given later, it can be argued that place must exist in the physical world. Our argument is going to insist that just as there has to be a matrix or substratum called matter in which two forms succeed one another, so it is necessary to hold that there is place in the world because there must be a where in which bodies in local motion succeed one another.[6] Moreover, our argument will say, place is not only a reality but it is also something distinct from the bodies that are in it. For if the place of a body were not distinct from that body, then a body undergoing local motion would take its place along with it and would have the same place after the motion as before.[7] **Bodies that occupy the** same **place after local motion as before could not be said to undergo local motion or change of place. In other words, if place is not truly distinct from bodies that are in it, change of place becomes a contradiction.**

From a more positive viewpoint, local motion requires that the old place occupied by a body remain constant and unchanged when the body moves out of it and that the new place likewise remain constant and unchanged as the body moves into it.

At first sight, place seems to be some kind of receptacle in which bodies succeed one another and which itself remains constant throughout the change. As a first approximation, place may even be likened to a vessel which can be emptied of one thing and occupied by another and which, in the course of the process, remains distinct from the two bodies it contained.[8]

Place, then, would seem not only to exist but also to be distinct from the bodies that are in it.

c. *Evidence for Natural Place*

Experience attests that place has an attractive power and that it even exercises a kind of final causality. Heavy bodies near the earth tend earthward and not away from the earth. Our earth would be a far different thing from the ordered environment we experience around us if, say, iron should tend to occupy places now filled by the atmosphere and if the atmosphere in turn should tend to places now occupied by iron. As the order in the universe afforded evidence for final causality in general, so the local order that we experience, the arrangement of

heavy and light bodies near our earth, would urge that different kinds of bodies have places natural to them,[9] that they are attracted to these places when out of them, and that they tend to remain there when in them. The presence of gravitation, to use the suggestion of Copernicus, may account for the material or even efficient cause of this attraction between bodies;[10] but it does not dispense with the fact of final causality as the basic reason for the local order in the universe. In the light of what has previously been said, gravitation may explain the necessity due to prior causes; but the end states the reason for the necessity.[11]

II. EVIDENCE AGAINST THE REALITY OF PLACE

a. Common *Objections*

Nevertheless, there are strong arguments against admitting such reality as place and especially against admitting anything like the fixed or natural place discussed in the preceding paragraph.

First of all, if place exists, it would look as though place would have to be a body; and if it is a body, then when a body is in place there must be at least two bodies — the place and the located body — in the same "place."[12]

Second, place, if we admit that it exists, would seem to be a consequence of the quantified structure of mobile being. A thing is in a place by reason of its quantity. But quantity, as such, would not seem to be associated with place.[13] A point which is a unit having position cannot, for instance, be moved from one place to another. In a different place there would simply be a different point, and the point that we imagine as being moved remains immovably where it was before. Far from being distinct from its place and capable of coming to and going from a place, a point is identified with its place. At different places, a man remains the same man; but a point, in a different place, is a different point. As a point in a different place is a different point, so a line of the same length in a different place is a different line; and a surface and solid of the same dimensions are a different surface and a different solid when their place is changed.[14] In mathematics, in short, the place of a thing is not distinct from the thing that is in it; and if place flows from quantity, it might seem as though place does not have the reality we have ascribed to it as distinct from the thing that occupies place.

Such are at least two samples of reasoning which would give us pause in our argument that place is real.

b. *The Copernican Revolution*

But perhaps the most serious argument against the reality of place remains to be proposed. It is an argument that emerges with the Copernican system of astronomy. In the Aristotelian cosmology which Copernicus opposed, the earth was considered the center of the universe. According to this view also, heavy bodies, like iron, tended toward this center; and light bodies, away from it. High overhead, celestial bodies, constituted of a different kind *of* matter by comparison to bodies on earth, were thought by Aristotle to be circulating about the earth in that most perfect of all movements, motion in a circle.[15]

Claudius Ptolemy worked out a complicated mathematical system to account for the apparent motion about the earth of the sun, moon, and known planets; and even though a heliocentric theory was held by some of the learned minds in ancient Greece, the geocentric view of Aristotle and Ptolemy gained ascendancy in the ancient world. In fact, this view held sway over European learning for more than two thousand years — until Copernicus, in the sixteenth century, revived the heliocentric view of Aristarchus.[16]

Copernicus showed that the very complicated mathematics of Ptolemy could be greatly simplified if the sun, rather than the earth, were placed as the center of rotation in our world and if the earth and the planets were regarded as orbiting around the sun.

With his newly found telescope, Galileo strengthened the Copernican theory. He saw that Jupiter has moons revolving about it and surmised that therefore the earth may not be the privileged center of rotation in our world. Jupiter is also a center of rotation for certain bodies, Galileo argued. Why not consider the sun to be the center of our own astronomical system?

Kepler discovered several important laws which seemed to make the Copernican system more exact, and as a result, the heliocentric theory seemed to account for the facts more simply than the older Ptolemaic system. Lastly, in this sketch of the new astronomy, Isaac Newton framed a world picture in which both the celestial mechanics of Kepler and the terrestrial mechanics of Galileo were reduced to the same general law.[17]

The details of this whole story need not be recited here. Of present importance is the fact that the heliocentric system of astronomy enabled modern physics to present simpler and more universal equations concerning local motion than the geocentric system of Aristotle could

provide. The very simplicity and universality achieved by physics when it left behind Ptolemy and Aristotle are arguments in favor of the heliocentric theory of the heavens.

But why should these relatively recent developments, especially in astronomy, form a third objection against admitting that place is something real in our universe?

The reason is that heliocentric astronomy tended to destroy the view that there is a natural center, that heavy bodies tended toward the earth as to their natural place, and that light bodies tended away from the earth in order also to be in their own natural places.[18] In fact, the Copernican theory broke down the notion that there is such a thing as natural place at all. Place from this time onward was considered to be something quite relative; when local motion takes place a thing does not gain or lose anything natural to it but simply undergoes a change of relations, or, as Locke put it,[19] change of distance, with respect to other bodies. In their various laws to account for the behavior of heavy and light bodies, Galileo and Newton seemed to explain upward and downward movement much better than could Aristotle by his concept of place as a final cause.

The Copernican theory showed that the natural places of things, if they existed at all, were quite different from Aristotle's "natural places." Moreover, Newton seemed able to explain local motion without appealing to the causality of place and hence by means of purely mechanical causalities. Place thus grew to be an expendable item in natural science. From Newton's time down to our own, it is space rather than place which is of interest to the modern physicists, and it will be important later on in this chapter to investigate what is meant by space. Our purpose here is only to raise a problem, and the problem is whether or not place is necessary in order to explain our world, and whether place is natural or merely relative.

III. PRELIMINARIES TO A DEFINITION OF PLACE

a. *Summary of Evidence for Place*

Despite all of the difficulties concerning the nature of place, the facts alleged to show its existence cannot be denied. There remains the evidence that a thing which does not exist somewhere is not thought to have physical existence.[20] There is the even stronger evidence that in any local motion something distinct from the thing moved must remain

constant and unchanging.[21] This is place. In working toward a precise definition of place, a fourfold division of propositions regarding place is in order.

b. *Preliminary Steps to Definition*

1. The answer to the question: where? always states the container in which a body is. Place is therefore regarded as containing that which is in place, and as local motion plainly shows, this container must be distinct from the located body.[22]

2. The primary place of a thing must be equal to the thing that is located in that place. For example, consider the milk in a bottle; the place that actually contains the milk is neither larger nor smaller than the volume of the milk itself. It is exactly equal to that volume.[23]

3. Everything that is located must have a place simply because everything that has physical existence must exist somewhere.[24]

4. Finally, though it is necessary to abandon Aristotle's geocentric theory of what the absolute natural places of various things are, there is convincing evidence that there is some kind of natural place for each different kind of body. For there is a local order in the world and efficient causes alone are not enough to explain order. It is a matter of common observation and experience that, unless there is interference, heavier bodies arrange themselves differently from light ones. There must be a reason for this local order and that reason, as the reason for any order, must be one of final causality.[25] Otherwise, we have to say that the order in our world is one of coincidence.

IV. DEFINITION OF PLACE

a. *The Definition Explained*

With these preliminaries behind, the definition of place may now be approached. If it is to be a good nominal definition, it should first of all formulate what men think about when they speak of place and of local motion; second, it should solve the difficulties raised by those who deny the existence of place; third, it ought to enable us to understand the properties observed concerning place.

Accordingly, place may be defined as the innermost immobile surface of a surrounding body.[26] Tire example of water in a glass may help to clarify the various parts of this nominal definition.

1. Place is a surface. When water is in a glass, it does not compenétrate the glass as though it existed between the inside and the outside of the glass. The material of which the glass is made, rather than the water, occupies this region between the walls. To say that water is in the glass means that the water is contained by the inside surface.

2. The preceding sentence has made a transition to another aspect of our definition. Water is contained by the innermost surface of the glass as opposed to the outside surface that would be grasped by the hand in the act of drinking. Place is the innermost surface of a container or, as it is sometimes put, it is the first surface. The significance of this word is that the place of a thing is the first surface outside of the located body.

3. Place is an immobile surface. Our previous discussion of place has forced us to the conclusion that local motion is possible only if something at each end of the motion remains immobile and unchanged. This immobile term is place. If the place of a locally moving body were carried along with it, there could be no local motion at all because a body at the end of such a motion would have the same place as before.

But there is a difficulty in this context. Suppose that a ship is anchored in a river with water continually flowing by it. It would appear, in these circumstances, as though the surface of the water surrounding a ship is something mobile and in certain cases at least, if not in all, there is no such thing as an immobile surface.

In responding to this difficulty, it should be said that although the parts of the stream that touch the ship are materially mobile, i.e., there is a different matter or content touching the ship from one moment to the next, nevertheless the same order or form remains when new water replaces the old. Water thus changes its character as water but not its character as place. It is this order or form (not the content) of a surrounding body which constitutes the place of something else. If the ship happened to be standing in drydock, the water flowing around it might be removed, and air would then become the surrounding body. But the order or form of the air around the ship would then constitute the place of the ship. In other words, place involves only formal immobility, not material immobility.[27] In this respect, in the case of our glass of water, the place involved differs from the glass insofar as the glass can be moved without moving the place. Unless we are willing to admit such immobility on the part of place, it is necessary to admit that in local motion the place of a thing changes along with it.

4. Place is the surface of a surrounding body. The surface surrounding

a thing that is in place must be the surface of a body and not a purely geometrical surface. For a purely geometrical surface would not exist separately in physical reality; and as a geometrical surface only, it would make place something mathematical rather than physical in character. As surrounding a body, place is an adjacent or contiguous surface. It **cannot be continuous** with the body that is in it; for otherwise, it would be a part of the body in place and not something distinct. It is outside the thing that is in place as the first surface of a surrounding or containing body.[28]

In this connection too it might be pointed out that the movement of the various parts within a thing that is one, e.g., the movement of the molecules in a living organism, is not a movement in place. Such movements are in the order of posture or situs. A thing possessing such movements would be said to be undergoing local motion but only in some accidental way. Thus a sleeping dog could be said to be essentially at rest but accidentally and by reason of its parts to be in motion.

b. *Answer to Difficulties*

Tire difficulties against admitting the reality of place can now be confronted. Tire first one was that if place is something real, then, when a thing is in place, there are two bodies — the place and the located body — in the same "place."

In reply to this objection, our definition of place has emphasized that place is a surface. It is not coterminous with the body that is in place. It does not overlap such a body. It surrounds it as something contiguous and adjacent. Hence, although place is of a body, i.e., the surrounding body's surface, place is not a body, and location does not require that there be two bodies in the same place.[29]

Our second difficulty proposed that since quantity, mathematically considered, does not involve place (because the position of any mathematical entity like a point is identical with such an entity), therefore place in physical reality does not exist as something distinct from things that are in place.

But this objection does not take account of the difference between the mathematical and physical orders. Place must be distinct from the thing that is in it, as local motion shows. Place must in fact be outside the located body in order to be separable from that body in local motion. Unlike a mathematical body terminated by its own outer surface, physical bodies always have surfaces of other bodies adjacent to them and sur-

rounding them.[30] Position is in the essence of a mathematical entity; but it is something outside the essence of a physical entity and is determined by what surrounds the physical entity in question.

The third difficulty which substitutes space for place and mechanical forces for final causality requires more explanation than our first two objections, and in order to face the problem, it is necessary to distinguish between space and place.

V. SPACE: A MATHEMATICAL ENTITY

a. *Definition of Space*

The space of a body is its internal extension.[31] Tire space of the world is the sum of the extensions of all bodies in the world.[32]

Now it was argued earlier that accidents come to a substance in a certain order. First there is quantity and then the sensible qualities.[33] These sensible qualities are, as it were, received into the complex of substance plus the quantity of a thing. Hence the mind may rightly consider the quantified substance of a thing as a receptacle for the sensible qualities which are directly observed with our senses as here or there. Such quantified substance constitutes the reality of space, and the sensible qualities constitute the content of space. The mind considers quantified substance to be a receiver and what is sensibly observed, the sensible qualities, to be received. Outside the mind, then, there is no distinction between space and the quantified substance which is the substratum of sensible quality.[34]

b. Space as *Mathematical*

Space is thus a mathematical, rather than a physical, entity,[35] and it can be considered only to the extent that we are interested in the mathematical or metrical properties of things. Place, on the other hand, is physical; it can be known only as the term of local motion. The space of a thing is synonymous with its internal dimensions; the place of anything is not internal to it but external. The space of the world is the sum of all spaces in the bodies of the world.

Space does not answer the question where? but the question how much? e.g., how much greater is a billiard ball than a buck shot? Now the question where? is a reasonable and legitimate question, even though it cannot be answered in terms of quantity alone. Thus, our usual proposi-

tion that the sun is 93 million miles distant from the earth is more than merely quantitative in character. Were it only quantitative, the proposition would simply say that a quantity is 93 million miles. But such a strictly quantitative proposition by itself would be meaningless to express a physical state of affairs. In order to make it meaningful, it is necessary to add physical references like the sun and the earth. It is necessary to say that the sun is 93 million miles distant from the earth, or something to that effect. Quantity, the answer to the question how much? cannot by itself respond to the question where?

But once we know — through the general physical knowledge which precedes the more refined and mathematical-physical study of nature — what we mean by where, we can supplement our general knowledge by the exact and metrical reports of matter available through modern physics. Once we know place as a physical measure we can learn more about it through the mathematical techniques that enable us to measure and refine but do not by themselves tell us what we are measuring and refining. This is another example of the relation between the general science of nature and its specialized branches. The second specifies and clarifies what the first knows only in a vague and general way.

VI. NATURAL PLACE

a. *Gravitation Not Enough*

Place, it was observed, is something physical and natural, while space is more mathematical in character. Hence, despite the mathematics of Copernicus and Kepler, Galileo and Newton, the view' of place as physical need not be abandoned. Moreover, gravitation alone cannot account for the arrangement of bodies which experience reveals to us; and so place must be still accepted as the final cause of this order. For gravitation, in whatever reality it has, is a mechanical force in the order of material or efficient causality; if it alone were responsible for the order of the world, that order as in all mechanism would have to be ascribed to chance. Hence, though it is necessary to scrap the Aristotelian theory that the earth is the center of the universe and that the natural place of heavy bodies is near this center, it would not be logical to deny all meaning to the notion of natural place. Aristotle erred in determining what the places of things are, but this is a different question from the one appropriate to our general science: whether there are natural places. It can surely be argued that in local motion, for example, in

upward and downward motion with respect to the earth, we have to ascribe the outcome of the motion to chance or say that every body will do what is most suitable to its nature under the circumstances; in other words, it will behave in obedience to place as a final cause.[36] Only thus can the local order of the world be explained.

b. *Order Argues Finality*

To say that a body in local motion will do what is most fitted for its nature under the given conditions of its movement does not enable us to deduce what, under these conditions, is the natural place of the body in question. That depends on empirical investigation. The discovery that there is natural place is a different question from determining what such a place is in the case of this or that body in these or those circumstances. Even if we never found the natural place of a single thing, the local order in the world would tell our general science that in any given state of the universe there are natural places corresponding to every kind of thing. Such natural place is the final cause of natural local motion.[37]

c. *Everything Mobile Is in Place*

That everything locally mobile is in place can be demonstrated by the following causal (propter quid) argument:

Whatever is surrounded by a first immobile surface of a containing body to which it is moved or in which it is at rest	is in place.
Everything mobile as the subject of motion	is surrounded by a first immobile surface of a containing body to which it is moved or in which it is at rest.
Therefore, everything mobile as the subject of motion	is in place.

The major proposition is evident from our definition of place. The minor is evident from the principle of finality; every motion must have a term, and such a term must be in act, hence not movable, if local motion truly occurs.

VII. THE VACUUM

a. *Evidence for a Vacuum*

The question of place gives rise to a kindred problem: the problem of the vacuum. If place is the first immobile surface of a surrounding

body, a vacuum may be defined as a place without a body occupying it. It is a place deprived of tangible matter.[38] Does such a phenomenon exist? Or must we rule out a vacuum as physically impossible?

From antiquity to our own day, students of the physical world have discussed the problem of the vacuum, and many have concluded that a vacuum actually exists. The ancient atomists, like Democritus and Leucippus, argued that voids or vacant spaces were required in nature in order to permit local motion. If the universe were full, that is, if the universe were a plenum, the atomists argued, then local motion would be impossible; bodies, they said, could not move in a plenum to other places because all such places would be already filled with other bodies that occupied them. But such local motion does occur, the atomists pointed out, and hence, they concluded, we must admit the existence of a vacuum so that moving bodies would have some place to go.[39]

Another argument, likewise drawn from atomism, takes its rise from the fact of condensation and rarefaction in nature. Water, when converted into steam, occupies a greater volume than water in a liquid state. A quantity of air can be compressed into a smaller space. According to atomism such facts require that we admit voids between the small particles in nature so that a quantity of matter, when compressed, can allow the small particles to move closer and closer together and, when expanded, to move farther and farther apart.[40]

On the modern scene, ever since the work of Guernicke, Boyle, and Galileo, men have spoken of a vacuum, and with the vacuum sweeper of the modern home and the vacuum tube of modern electronics, the vacuum has become a household word. Tire vacuum as understood by Boyle and Guernicke is a volume of the physical world, from which, by means of a pump, so-called ponderable or massive matter has been exhausted.[41] It is true that there are practical difficulties about the creation of a vacuum by experimental means and no one would claim that from the practical point of view a perfect vacuum can be achieved even though remarkable approximations to a perfect vacuum have been reached. But the achievement of Boyle and Guernicke and their successors raises the central problem of whether a vacuum, apart from the practical difficulties of producing it, is at all possible in principle.

b. *Arguments Against a Vacuum*

If we take a vacuum to mean an absence within the world of everything, corporeal and material, then a vacuum is not only impractical

on account of the difficulties in creating it, but in the strict sense of the term, it is impossible in principle. Arguments against its physical existence can be drawn from physical considerations, i.e., from a consideration of things in terms of their motions.

In the first place, contrary to atomism, it is not necessary to posit a vacuum in order to explain local motion, for the nature of a thing can explain its natural movement.[42] What is natural, as we have seen, has a principle of motion within itself. Such a principle in any mobile being can explain the motion of that being. Motion comes from within things and not from the absence of external impediments. That is to say, when one thing displaces another, the two motions involved can be explained by the principles original to each of the two things without having recourse to the existence of a vacuum. A man removing a blindfold from the eyes of another person does not cause that other person to see; the fundamental cause or principle of sight is in the man who sees, not in the remover of the blindfold. The man removing the blindfold causes another person to see only in an accidental way, by removing the impediment.[43] In a similar way, things that undergo local change have principles of motion within themselves and by their ordered motions make our universe an ordered world. To make the absence of resistance a cause of local motion is like making the remover of a blindfold the cause of sight. *If* we can explain the motions of the world by means of the natures in the world, it is not necessary to allege the existence of a vacuum.

Second, if place is necessary in order to explain local motion, a vacuum would not only be unnecessary to explain such motion but would even make the local motion impossible. The local order in the universe, we have argued, requires us to conclude that all things in local motion seek the places most suitable to their natures under the given causes and conditions. However, if a vacuum is mere emptiness, there is nothing to make one part of it more or less suitable to a body. There would be no good reason why a body moving through a vacuum should be in one "part" of it rather than another since each part would be equally indifferent to the presence of the moving body and one part would thus not be more suitable than another.[44] If a void does not have a differential structure, there is no reason why a body should be moving in this part of it rather than that. What would be the meaning of here and there in absolute emptiness?

Third, where there cannot be natural motion there cannot be any other kind of motion,[45] e.g., violent motion. Now violent movement is

motion from outside the nature of the thing moved so that the nature does not confer anything to the movement;[46] an example of violent motion is the throwing of a stone in an upward direction. Now if violence can exist only as contrary to the nature of a thing, there must be nature before there can be violence. Hence, if there cannot be natural motion in a vacuum, there cannot be violent motion there either.

Thus, whatever Boyle, Guernicke, and their successors may have achieved and may still be achieving in exhausting ponderable matter from a container, they cannot remove the corporeal and the material from any portion of space. They do not produce truly empty space. As shown by electromagnetic and gravitational phenomena, what is called a vacuum, e.g., the space inside a vacuum tube, has a field structure; the so-called vacant space is differentiated from point to point as shown by the path of electrons which varies according to the direction and strength of the electrical and magnetic fields. Now emptiness cannot be differentiated from point to point; it has no strength or weakness or direction of field lines, and so even on experimental grounds, it can be seen that a vacuum, whatever else it may be, is not truly empty.[47] The Newtonian theory of mass and the Daltonian theory of atoms have propagated perhaps some faulty notions of what matter is. As the relativity theory has reminded us, what is material need not take the form of little blobs of ponderable stuff; matter has a much wider meaning. According to this meaning, whatever involves the mobile is material,[48] and in this light, electromagnetic and gravitational fields within a so-called vacuum show that such apparent emptiness is really material because it affects mobile being traveling through it.

As Leibniz said, nature shrinks from a vacuum. Water rises in a suction pump in order to prevent emptiness from occurring in nature. A vacuum would be a disorder in the world. In order to prevent it, the water in the pump violates its own nature and rises so that order in the universe as a whole will be preserved. Without that local order in the universe as a whole nothing would survive, and hence all material things tend to promote that good of the whole world. As necessary to the very survival of all things, the order in the universe as a whole is in some manner connected with the good of all things, and hence all things tend to prevent disorder insofar as it is within their power. A vacuum, as a place deprived of body and hence as emptiness, would be such a disorder. Nature shrinks from it.[49] Such a judgment refers to final causality; we should not imagine the final cause as an efficient cause "drawing" or "sucking" anything into itself.

VIII. SUMMARY AND CONCLUSION

Place, as the innermost immobile surface of a surrounding body, is a measure of mobile being. It is a measure because it reduces mobile being to an organization by binding it within certain limits. Unlike space, which is an internal measure of matter, it is extrinsic to the being in question. Place is a measure of mobile being rather than merely of motion because the place of a thing is determined by the character or nature of the mobile being itself. Time, on the other hand, is a measure of motion, as will be shown later.

Place is proved to exist by means of a factual demonstration, in which the middle term is our nominal definition.

> The innermost immobile surface of any surrounding body exists.
> Place is the innermost immobile surface of a surrounding body.
> Therefore, place exists.

The major premise of this syllogism is established by induction. The data for such an induction are the local motions in nature, where, it can be observed, there must be one unchanging surface surrounding the body at the beginning of its motion and another first immobile surface of a surrounding body at the end. Without those two unchanging terms, local movement could not occur. Place, as nominally defined in our minor premise, therefore exists.

Moreover, in spite of the demise of the geocentric theory of astronomy, it can still be maintained that every kind of body has its own proper natural place; this is to say, every body in local motion seeks the environment most suitable to its nature in the set of circumstances in which it is acting. Gravitation can inform us of prior causes in natural local motion, but it requires place as a final cause to give the ultimate reason for the local order in our world.

Space and place should be distinguished. Space is the internal extension of a body. It is the quantified substance imagined as a receptacle for the sensible qualities which we observe in things. Space is a mathematical reality, whereas place is physical. Space is homogeneous and has no aspect of final causality. Place is heterogeneous — some places are more suitable than others for this or that body — and place also is a final cause.

The opposite and, in a sense, the contrary of place is the vacuum, defined as a place deprived of body. Several arguments were given that it is not necessary to imagine a vacuum in order to explain local motion.

However, since what is empty cannot be differentiated from point to point, it would be illogical to consider so-called vacuum as empty of the corporeal and the material.

REVIEW QUESTIONS

1. Why does it belong to the science of nature to consider place?
2. What evidence is there for place? for natural place?
3. What evidence is alleged against the reality of place?
4. Explain how the Copernican theory affected the notion of place.
5. How does modern physics explain the changes which are called local motions?
6. What are some divisions necessary to the understanding of place?
7. Define place and explain each part of this nominal definition.
8. Explain how our definition of place can answer some difficulties regarding the nature of place.
9. Define space and contrast it with place.
10. What is the real status of space?
11. Why is space called a mathematical entity?
12. What argument can be given for natural place?
13. Why is gravitation alone unable to explain local order?
14. Do we have to name the natural places of things to know that they have such places? Explain.
15. What is the evidence for the possibility of a vacuum?
16. What arguments can be given against this possibility?

PROBLEMS

Compare the following passages with the material covered in this chapter:

I

"What then after all is place? The answer to this question may be elucidated as follows.

"Let us take for granted about it the various characteristics which are supposed correctly to belong to it essentially. We assume then —

(1) Place is what contains that of which it is the place.
(2) Place is no part of the thing.
(3) The immediate place of a thing is neither less nor greater than the thing.
(4) Place can be left behind by the thing and is separable.

In addition:

(5) All place admits of the distinction of up and down, and each of the bodies is naturally carried to its appropriate place and rests there, and this makes the place either up or down.

"Having laid these foundations, we must complete the theory. We ought to try to make our investigation such as will render an account of place, and will not only solve the difficulties connected with it, but will also show that the attributes supposed to belong to it do really belong to it, and further will make clear the cause of the trouble and of the difficulties about it. Such is the most satisfactory kind of exposition.

"First then we must understand that place would not have been thought of, if there had not been a special kind of motion, namely that with respect to place. It is chiefly for this reason that we suppose the heaven also to be in place, because it is in constant movement. Of this kind of change there are two species — locomotion on the one hand and, on the other, increase and diminution. For these too involve variation of place: what was then in this place has now in turn changed to what is larger or smaller.

"Again, when we say a thing is 'moved,' the predicate either (1) belongs to it actually, in virtue of its own nature, or (2) in virtue of something conjoined with it. In the latter case it may be either (a) something which by its own nature capable of being moved, e.g., the parts of the body or the nail in the ship, or (b) something which is not in itself capable of being moved, but is always moved through its conjunction with something else, as 'whiteness' or 'science.' These have changed their place only because the subjects to which they belong do so.

"We say that a thing is in the world, in the sense of in place, because it is in the air, and the air is in the world; and when we say it is in the air, we do not mean it is in every part of the air, but that it is in the air because of the outer surface of the air which surrounds it; for if all the air were its place, the place of a thing would not be equal to the thing — which it is supposed to be, and which the primary place in which a thing is actually is.

"When what surrounds, then, is not separate from the thing, but is in continuity with it, the thing is said to be in what surrounds it, not in the sense of in place, but as a part in a whole. But when the surface of the surrounding body, and this surface is neither a part of what is in it nor yet greater than its extension, but equal to it; for the extremities of things which touch are coincident."

Aristotle, *Physics*[60]

II

"Hitherto I have laid down the definitions of such words as are less known, and explained the sense in which I would have them to be understood in the following discourse. I do not define time, space, place and motion, as being well known to all. Only I must observe, that the vulgar conceive those quantities under no other notions but from the relation they bear to sensible objects. And thence arise certain prejudices, for the removing of which, it will be convenient to distinguish them into absolute and relative, true and apparent, mathematical and common.

"I. Absolute, true, and mathematical time, of itself, and from its own

nature, flows equably without regard to anything external, and by another name is called duration: relative, apparent, and common time is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time; such as an hour, a day, a month, a year.

"II. Absolute space, in its own nature, without regard to anything external, remains always similar and immovable. Relative space is some movable dimension or measure of the absolute spaces; which our senses determine by its position to bodies; and which is vulgarly taken for immovable space; such is the dimension of a subterraneous, an aereal, or celestial space, determined by its position in respect of the earth. Absolute and relative space are the same in figure and magnitude; but they do not remain always numerically the same. For if the earth, for instance, moves, a space of our air, which relatively and in respect of the earth remains always the same, will at one time be one part of the absolute space into which the air passes; at another time it will be another part of the same, and so, absolutely understood, it will be perpetually mutable.

"III. Place is a part of space which a body takes up, and is, according to the space, either absolute or relative. I say, a part of space; not the situation, nor the external surface of the body. For the places of equal solids are always equal; but their superficies, by reason of their dissimilar figures, are often unequal. Positions properly have no quantity, nor are they so much the places themselves, as the properties of places. The motion of the whole is the same thing with the sum of the motions of the parts; that is, the translation of the whole, out of its place, is the same thing with the sum of the translations of the parts out of their places; and therefore the place of the whole is the same thing with the sum of the places of the parts, and for that reason, it is internal, and in the whole body.

"IV. Absolute motion is the translation of a body from one absolute place into another; and relative motion, the translation from one relative place into another. Thus in a ship under sail, the relative place of a body is that part of the ship which the body possesses; or that part of its cavity which the body fills, and which therefore moves together with the ship: and relative rest is the continuance of the body in the same part of the ship or of its cavity. But real, absolute rest is the continuance of the body in the same part of that immovable space, in which the ship itself, its cavity, and all that it contains, is moved. Wherefore, if the earth is really at rest, the body, which relatively rests in the ship, will really and absolutely move with the same velocity which the ship has on the earth. But if the earth also moves, the true and absolute motion of the body will arise, partly from the true motion of the earth, in immovable space; partly from the relative motion of the ship on the earth; and if the body moves also relatively in the ship its true motion will arise, partly from the true motion of the earth, in immovable space, and partly from the relative motions as well of the ship on the earth, as of the body in the ship; and from these relative motions will arise the relative motion of the body on the earth.

As if that part of the earth, where the ship is, was truly moved toward the east, with a velocity of 10010 parts; while the ship itself, with a fresh gale, and full sails, is carried towards the west, with a velocity expressed by 10 of those parts; but a sailor walks in the ship towards the east, with 1 part of the said velocity; then the sailor will be moved truly in immovable space towards the east, with a velocity of 10001 parts, and relatively on the earth towards the west, with a velocity of 9 of those parts."

Newton, *Mathematical Principles of Natural Philosophy*™

NOTES TO CHAPTER XV

1. *Com. on the Phys.,* Bk. Ill, les. I, n. 543; Bk. IV, les. 1, n. 784.
2. *Ibid.,* Bk. IV, les. 1, n. 786; *Phys.,* Bk. IV, ch. 1, 208a, 30.
3. This introductory discussion is not the place to treat John of St. Thomas' extrinsic place and intrinsic place or *"ubication."* Cf. Curs. Phil., Phil. Nat., I, P. Q. XVI, ed. Reiser (Turin, 1930), II, 335 ff.
4. Phys., Bk. IV, ch. 1, 208a, 32; Com. on the *Phys.,* Bk. IV, les. 1, n. 788.
5. Summa Theol., I, q. 2, a. 2; Exposition of *the Post. Anal.,* Bk. I, les. 23, n. 197.
6. Phys., Bk. IV, ch. 1, 208b, 1-3; Com. on the *Phys.,* Bk. IV, les. 1, n. 791.
7. On Truth, q. 1, a. 6.
8. Com. on the Phys., Bk. IV, les. 1, n. 792.
9. *Ibid.,* n. 793.
10. On the Revolution of the Heavenly Spheres, "Great Books of the Western World," XXVI, 521.
11. Cf. supra, Chapter XI, p. 229.
12. Com. on the Phys., Bk. IV, les. 2, n. 803.
13. Com. on the Met., Bk. XI, les. 10, n. 2339.
14. Com. on the *Trin.,* q. 4, a. 2, reply 3.
15. For a short discussion and diagram of Aristotle's cosmos, cf. J. McWilliams, *Physics and Philosophy* (Washington, 1945), pp. 3-6.
16. For a history of the astronomical problem, cf. J. Dreyer, *A History of Astronomy, From Thales to Kepler* (New York, 1953).
17. The events leading up to Newtonian science, together with the meaning attached to Newton's achievement, are treated in A. Burtt, The Metaphysical Foundations of *Modern Science,* 2 ed. (New York, 1932); cf. also G. Ardley's "The Physics of Local Motion," *The Thomist,* XVII (1954), 145-185.
18. *Phys.,* Bk. VIII, ch. 4, 255b, 15-17.
19. Essay on the Human *Understanding,* ch. xiii, 14.
20. Com. on the Phys., Bk. IV, les. 1, n. 786.
21. *Ibid.,* nn. 791-792.
22. Ibid., les. 5, n. 860.
23. *Ibid.,* n. 861; Com. on *the Trin., q.* 4, a. 3.
24. Com. On *the Phys.,* Bk. IV, les. 5, n. 862; Sum. *cont. Gent.,* Bk. II, ch. 13. The universe as a whole is not included here. It is not a "thing" and it does not have a "where."
25. Com. on *the Phys.,* Bk. IV, les. 5, n. 863; Com. on On the Heavens, Bk. I, les. 16 ff.
26. *Phys.,* Bk. IV, ch. 5, 212a, 20-21.
27. *Phys.,* Bk. IV, ch. 4, 212a, 15-18; Com. on the *Phys.,* Bk. IV, les. 6, nn. 896-900.
28. Com. on *the Phys.,* Bk. IV, les. 6, n. 893 ff.
29. Summa *Theol., I,* q. 8, a. 2.
30. Except the bodies on the outer frontier of the universe which, if at rest, are in place by reason of their parts but not in place in a primary manner. Phys., Bk. IV, ch. 5, 212b, 12-15; Com. on the *Phys.,* Bk. IV, les. 7, nn. 928-932.
31. Com. on the *Phys.,* Bk. IV, les. 7, n. 909; les. 10, nn. 970-971.
32. This seems to be Newton's notion, cf. *The Mathematical Principles of Natural Philosophy,* transi. A. Motte, rev. F. Cajori (Berkeley, 1947), p. 6.

33. If space is nothing apart from the dimensions of bodies, it is no wonder that Bradley cannot find it. "It is lengths of lengths of nothing that we can find." Appearance and Reality, p. 37.
34. The problem of whether space is empty or full, real or ideal, is the subject of an historic controversy between Newtonians and Leibniz. Cf. *The* Leibniz-Clarke Correspondence, ed. N. Alexander (New York, 1956). Our solution makes only a mental or logical distinction between space and quantified substances "occupying" space. It would be better to say that space or the quantified is occupied by the sensibly qualified.
35. Com. on the Phys., Bk. IV, les. 11, n. 992.
36. Ibid., Bk. IV, les. 5, nn. 793-794; cf. J. Weisheipl, "Space and Gravitation," *The New Scholasticism,* XXIX (1955), 175-223.
37. Com. on the Met., Bk. XI, les. 12, n. 2627.
38. For three definitions of a vacuum, cf. Com. on the *Phys.,* Bk. IV, les. 10, n. 969.
39. Phys., Bk. IV, ch. 7, 214a, 23-26.
40. For a study of theories on condensation and rarefaction and the relevance to this problem of the study of the vacuum, cf. G. Holton, *Introduction to the Concepts* and Theories in Physical Science (Cambridge, Mass., 1952), pp. 367-395.
41. Cf. J. Conant, On Understanding Science (New Haven, 1947), pp. 29-64.
42. Phys., Bk. IV, ch. 8, 274b, 13-17; Com. on the Phys., Bk. IV, les. 11, n. 989.
43. Com. on the Phys., Bk. VIII, les. 8, n. 2176.
44. Phys., Bk. IV, ch. 8, 214b, 30-35.
45. Sum. cont. Cent., Bk. II, ch. 82.
46. Com. on the Eth., Bk. III, les. 2, n. 405.
47. H. Van Laer, Philosophic-Scientific Problems, trans. H. Koren (Pittsburgh, 1943), p. 101 ff.
48. Com. on *the Phys.,* Bk. I, les. 1, 3.
49. John of St. Thomas, Curs. Phil., Phil. Nat., I. P. Q. XVI, ed. Reiser, II, 335 ff.
50. Bk. IV, ch. 4, 210b, 33-21 Ia, 34.
51. Translated by A. Motte, rev. by F. Cajori (Berkeley, 1947), pp. 6-7. Reprinted with permission of University of California Press.

CHAPTER XVI

TIME, THE MEASURE OF MOTION

I. DIFFICULTY OF OUR QUESTION

a. *An Historical Problem*

Time is even more difficult to grasp than place. "What then is time?" St. Augustine asks, and he answers, "If no one asks me, I know; if I want to explain it to a questioner, I do not know."[1]

Time, indeed, is quite an apparent fact of our experience. There are few things more evident to us than the existence of time. Yet, when we come to formulate our knowledge into a definition in order to explain time to a questioner or even to ourselves, is it not very easy to agree with St. Augustine?

In previous chapters we have seen that science, in the modern sense and as historically evolved, makes no explicit reference to the four causes. It does not pause to define motion, nor does it give a full-blown treatment to place, since the concept of space is of greater interest for a purely metrical approach to nature.[2] But the concept of time is a different question. It is a perennial problem for Western thinkers and is as much a matter of concern for contemporary scientists as it was for the Greeks. Time has been a problem for students of nature in antiquity and in the modern period. Surely one of the chief occupations of the modern physicist is to compute and measure time-intervals in the movements of matter. Time is likewise a favorite subject for poets.[3] But what is this reality called time that the modern physicist is anxious to measure? What is the ordinary person telling when he looks at the

clock? He is telling time, we answer; but what is the time that our clocks measure?

Science in the modern sense of the term tells time by the measurements that it makes, but it does not tell us what time is. Only a pre-metrical and pre-experimental analysis can answer that question. And this answer is, therefore, presupposed by laboratory measurements. Hence it ought to be thought out carefully if we are to avoid the small error in the beginning of an investigation which will lead to a large one by the end. Here, as elsewhere, the general science of nature must precede the specialized and more exact knowledges of nature if we are to know what it is that we are measuring in the modern laboratory or with our latest telescope. We have to know what time is in order to measure it. intelligently, and there is evidence that the modern scientist begins his study of nature by accepting the ordinary common-sense notions of what time is, without bothering to submit those notions to proper analysis and criticism. The general science of nature, going back to what is first in the solution of physical problems, can furnish a definition of time that will make modern measurements in the physical world all the more meaningful.

But such a definition is not easy. In the first place, there are two opinions, diametrically opposed to one another, concerning the type of existence which time enjoys. One of these extreme views maintains that time does not really exist. For the past, which is one part of time, is already over and hence does not have existence. The future, the other part of time, is not yet, and, like the past, cannot be said to have existence. Moreover the present is constantly passing, and because it is always passing, it does not seem proper to say that it is or exists. As composed of realities — the past, present, and future — which do not seem to exist, time itself does not appear to have a real existence.[1]

b. *Kant's Logical View of Time*

Immanuel Kant (d. 1804) held that the "awareness" of time is not derived from experience but must be prior to experience. Nothing can be recognized as being in the physical world, Kant held, unless we recognize it as existing in time. We can notice a moving stone only when we see it as taking time. The notion of time is thus in some way embedded in the mind before it can know a moving stone or any other item of experience. Since nothing mobile can be experienced without an awareness that it is in time, the mind's response to time must be in

some way prior to all experience whatsoever. Because it is prior to all sensible experience, Kant called time an **apriori form of sensibility.** It is a precondition of all experience, built into the very structure of the human intellect and projected upon the phenomena or appearances that arouse our senses into action.

Kant's position in this regard is important enough to be quoted at length:

> Time is not an empirical concept that has been derived from any experience. For neither coexistence nor succession would ever come within our perception, if the representation of time were not presupposed as underlying them a priori. Only on the presupposition of time can we represent to ourselves a number of things as existing at one and the same time (simultaneously) or at different times (successively).
>
> Time is a necessary representation that underlies all intuitions. We cannot, in respect of appearances in general, remove time itself, though we can quite well think time as void of all appearances. Time is, therefore, given a *priori.* In it alone is actuality of appearances possible at all. Appearances may, one and all, vanish; but time (as the universal condition of their possibility) cannot itself be removed.[5]

In assigning to time the status of an apriori form, i.e., something prior to all experience, Kant regarded time as a mental or, in the broad sense of the word, a logical reality. He saw that time was not given **after** experience; hence he alleged that time would have to exist, as a representation, before experience. He overlooked a third possibility, namely, that time is given with experience, neither before nor after it. Time and motion, it can be argued, are grasped initially in one vague idea which is later on progressively clarified and differentiated so that **time and** motion stand out as distinct. But we need not here pursue this subject any further.

C. *Bergson's Ultra Realism Regarding Time*

At the opposite pole from Kant, who took an overly logical view of time, is Henri Bergson (d. 1941), who believed that time is not only real outside the mind but also the very essence of reality. According to Bergson, the world, as grasped in our deeper penetration of it, is nothing but pure duration. We get to the heart of reality when we discover that things endure. This is their basic nature or essence.

Here are some of Bergson's pronouncements:

> He who installs himself in becoming sees in duration the very life of things, the fundamental reality.[6] . . . The duration of the universe must **therefore be one with the latitude of creation which can find place in it.**[1]

> . . . The painter is before his canvas, the colors are on the palette, the model is sitting — all this we see, and also we know the painter's style: do we foresee what will appear on the canvas? We possess the elements of the problem; we know in an abstract way how it will be solved, for the portrait will surely resemble the model and will surely resemble also the artist; but the concrete solution brings with it that unforeseeable nothing which is everything in a work of art. And it is this nothing that takes time. Nought as matter, it creates itself as form. The sprouting and flowering of this form are stretched out on the unshrinkable duration, which is one with their essence. So of the works of nature.[8]

Bergson was much impressed with the fact of change. Much of his work is designed to show that our intellect, in its ordinary knowledge, does not grasp change as it is; to think about change the intellect must stop it, "freeze" change. Bergson would not accept what we have previously called abstraction as a condition of genuine knowledge. Moreover, like Plato in the ancient world,[9] Bergson appears to have regarded time as movement, essentially the same as the "sprouting" and "flowering" described in the passage above. In this respect, while Kant took time to be logical or mental only, Bergson went to the opposite extreme of investing time with a fully real status like that of motion itself.

II. TIME AND MOTION*

a. *Time Not Motion*

But it is a mistake to identify time with any motion. In the first place, time is common to quantitative motion, qualitative change, and local motion. All such motions involve time. While each of these motions is going on, the same time is passing as our clocks can show, and far from being any particular motion, time is something that all motions have in common.[10]

Second, motion can be slower or faster. A slower motion is one that covers a given space in a longer time, while a faster motion is one that covers the same space in a shorter time. If time were motion, such expressions would have to be altered to read that a slow time is one that covers a given space in a long time, etc. In other words, time would be measured by time. But time does not go faster or slower; time is rather a constant, and it is the motions, which take time, that go faster or slower.[11]

Bergson, who seems to have held that there is one "substantial"

duration in the world and hence one over-all motion, would not have been impressed by arguments like the two we have given. To refute him on this score and to show that the world is not just one substance or one motion belongs to metaphysics or natural theology.[12] Bergson's view has been introduced into our discussion merely as a means of raising the problem: Is time truly real or only mental? Here it is sufficient to remark that if Bergson were correct, there could be no genuine meaning to the expression that motion takes time; for such a proposition implies that time is something different from motion. In other words, if it is true that motion takes time, time and motion cannot be identical.

b. *Time Never Without Motion*

But although time is not the same thing as motion, time is never without motion.[13] It is only because a mobile being is now here and now there that we are aware that time has passed. If everything, including ourselves, were absolutely immobile, we would be unaware of the passage of time and hence unaware of time's reality.[14] After a period of sleep, we are aware that time has passed because things have changed around us; the sun is rising, for instance, or the hands have turned on our clock. The duration of what is at rest in the world is determined by the motions of things around it. Time, in short, always involves motion; contrary to Kant, it is impossible to think of time "as void ***of*** all appearances," e.g., as empty of motion. Let the reader try it.

Hence, although time cannot be identified with motion, it always refers to motion in some essential way. Although Bergson was wrong in claiming that "unshrinkable duration" is one with the essence of things, his insight that time is inextricably involved in the essence of changing things is genuine and valid.

Contrary to Kant's account, we become aware of motion and of time in the same experience. Even in darkness, when we may be lying still in our bed unaware of physical motions about us and within our own bodies, there is at least a succession of images passing before our mind, and in recognizing this succession, we are aware also of time. In perceiving motion, we perceive time; and in perceiving time, we perceive motion. The two are correlative.[15] Hence, it may be concluded that our definition of time will have to include the reference of time to motion without, however, making time and motion absolutely the same reality. Our definition of time must show how time is related to motion and how the two differ from each other.

III. TIME AND QUANTITY

a. *The Prior and Posterior*

But there are other requirements that our definition will also have to satisfy. Time involves motion in the character of motion as spread out or quantified. In watching a leaf being blown across the yard by the wind, the mind perceives that the object is first in this part of the yard and, as the motion continues, in that part. There is in some way a priority and posteriority between this part of the trajectory of a moving body and that, i.e., the thing in motion is first in a prior part of the trajectory and then in a posterior part. Such an order between the prior and the posterior in this context is a quantitative order. It is a relation like that between two parts of a line in space. **Priority and posteriority here do not mean temporal priority and posteriority, for they would then beg the question; they mean rather spatial or geo**metrical priority and posteriority.[16] Hence, it is not correct to say that time involves motion according to a before and after, because before and after in their common English usage connote time itself. They are defined by time, and if they were included in our definition of time, they would render our definition circular. Priority and posteriority, as in our example of the leaf which is now in this part of the yard and now in that, are of a local or quantitative or geometrical character. Tire leaf is in the prior part of its trajectory and, as the motion becomes more complete, it is in the posterior part; such an order in the parts of the pathway of a moving body makes us aware of time.

b. *Motion Through Quantify*

By now it must be apparent that we had to discuss geometrical quantity and also place before the nature of time could be properly analyzed. The prior and the posterior, the here and the there of place, are involved in time's reality; without them we would be unaware of time; furthermore, if motion had to cross an infinity of points, there would be no here and there as truly related to each other in any extended and local way.[17]

In a primary way, time is determined through local motion or motion through magnitude. Other motions, however, could also reveal to us the reality of time. For instance, time might be told by observing how long it took a standard piece of litmus paper to change its color in a fixed

quantity of a standard acid or by measuring how long it took a given electric current to decompose a standard quantity of water. Such methods of telling time would apparently involve non-quantified changes rather than local motion. But on closer inspection, it would be found that our suggested methods of time-telling would both require reference to quantity. In the case of the litmus paper, the reaction — and hence the measurement of time — would depend upon how much acid there was and how much paper we had; and in the electrolysis of water, our time-telling would depend on the quantity of water decomposed. The how much or the quantified is always involved in time, as experience reveals to us. "How much time did a motion take?" is a meaningful question.[16]

In the measurement of time, it is necessary to have some kind of continuity between the prior and posterior because, as experience attests, time does not move by leaps and bounds.[19] Furthermore, as in every measure, we ought to seek as a standard what is simplest and most uniform and, above all, most obvious in the order involved.[20] For a number of reasons then, time is measured by local motion in the order of magnitude, by continuous motion in the order of place, and it is primarily because a thing is now here and now there in place that we are aware that time has passed. Such motion, because of the fairly **uniform, continuous quantity in its trajectory, is the best means of determining time.** Priority and posteriority, as they occur in the definition of time, refer to the quantitative parts in the trajectory of a body in local motion.

There are in fact three kinds of priority and posteriority that might be confused. In the first place, there is the **temporally** prior and posterior, the **before** and after, which are the past and the future of time itself and which cannot be included in our definition without begging the question. Second, **motion** itself has a kind of prior and posterior insofar as a moving thing was previously in potency and later in act. The prior in motion is potency by comparison to the posterior as act. But once again this is not the meaning of the prior and the posterior in our definition of time. The prior and posterior which are going to occur in our definition are a third type. They are the local or quantitative prior and posterior, the order among the quantitative parts in the trajectory of a mobile being. Motion, it was argued, makes us aware of time. It does so primarily insofar as it is local motion because local motion is most clearly a motion involving quantitative parts with an arrangement of the prior and posterior among them.

IV. TIME AND NUMBER

a. We *Number the Prior and Posterior*

So far, then, our inductive search through general experience has yielded two items for our definition of time. Time involves motion, and time refers to the prior and the posterior in the pathway of a moving thing.

There is yet another element that our definition must include. When we are aware of time to the extent that we distinguish the prior and the posterior in motion, we are in some way actually counting the parts of quantity traversed by a motion; we are saying that this part, as the motion proceeds, is first or prior and that this other part is second or posterior. We recognize the prior and the posterior by numbering them, saying that the one is first and the other is second.[21] Since the motion is continuous, there is always a fraction that could have been counted in between the prior and the posterior we choose to count. It is, of course, not necessary to use distinct numbers like "first" and "second" in order to be aware of time, but there is always a vaguely known succession of parts, a confused awareness of prior and posterior parts, an implicit counting of a first and at least a second in the trajectory of a moving body.

Tliere are at least two parts involved in time: the past which corresponds to the prior part of a trajectory already covered by the thing moved; and the future which corresponds to the posterior part of the trajectory that the motion has yet to traverse. When we number the parts of such a trajectory, recognizing that the **here** is first and the **there** is second, we are aware of time. **Time, then, is a number or measure of motion according to the prior and the posterior.**[22]

b. *Time Is to a Line as Now Is to a Point*

It may be useful to consider time as being somewhat similar to a line. Before beginning, however, we ought to emphasize that we are here merely comparing time to something we already know from mathematics, i.e., a line, and there is no pretense that our comparison is anything more than a pedagogical device. **Time, unlike a line, exists only successively but never with all of its parts simultaneous. A line, on the other hand, has its parts simultaneously present. Hence there**

is a decisive difference between time and anything merely geometrical.[23]

In the light of our comparison, the now or instant is like some point on a line.[24] One part of the line represents the past and the other the future. But what do we mean by the now? Is the now the same thing as the present? Is the now truly a part of time, or does it have some other status? A weighing of these questions will help us to a better understanding of what time is.

Unlike the point on a line, the now is always flowing.[25] If a point be considered to undergo an imaginary motion, it would be regarded from one angle as the same point that was being moved; but to the extent of being in motion, the point would likewise always be different. It would be the same subject with constantly changing relations.[26]

So also with the now. The now does not go out of existence in the past in order to come back into existence in the future. Time is like our line generated by our point in imaginary motion, and the now is like the point itself. Time is generated by the now flowing. The now has a continuous existence as it flows through time; but as always flowing, this continuous existence must always be different. This is the reason why the now, as flowing, can unite the past to the future in a continuous flow and still leave them differentiated. How is this twofold function possible on the part of the now?

The now is like a moving point; time is like a line. In the framework of another comparison, time is related to motion as the now is related to mobile being.[27] Hence, as mobile being is twofold in character, so is the now. Throughout any motion, there is something of the mobile being that remains constant in time, thus giving to time a continuity like that of local motion itself, but there is also something that does not remain constant. The twofold character of the now can be brought out best if we remark that the now is the term of the past and the principle of the future. Hence, the now can have a twofold function.

C. *The Present*

There are two parts of time, the past and the future, and the now unites and divides them. The present is not the same as the now, and neither is it a part of time distinct from the past and the future. The present day, as a reader is taking in these lines on this page, includes some of the past and some of the future, going back to the beginning of today and continuing until midnight tonight. The same judgment could be made about the present hour; it includes some of the past and

some of the future. The same could be said of the present minute or present second or the present subdivision of a second, however small it be made. Returning to our analogy with the line, there is no smallest part of time just as there is no smallest and indivisible part of a line.[28] **What is called the present day or present hour or present second includes a portion, more or less great, of both the past and the future.** What is called the present, without designating the interval, is some indefinite portion of the past, however great or small, joined with some indefinite part of the future, again however great or small. Such a present held before the mind, because of reason's synthetic reach into the past and the future, is often called the specious or psychological present. But if time involves a continuous flow and may be likened to a line, there is no smallest or indivisible part of it that can be isolated as the physical present.

V. THE NOW AS TWOFOLD

a. *The Two Functions of the Now*

***The* now** is thus not the same thing as the present. The **now** is not, as is the present, a synthetic unity of part of the past with part of the future. In fact, the **now** is not even a part of time,[29] just as a point is not part of a line. As a point on a line divides two parts of a line from each other and also joins them but is not part of the line itself, so the **now** divides time into its two parts, the past and the future, without itself being a part of time.

As a point both distinguishes two parts of a line from each other and continues them with each other, so does the now in regard to time. **It is the term of that part of time which we call the past and the principle of that part which we call the future. The** only difficulty with our analogy is that the point is immobile but the **now** is always flowing.

b. *Reason and the Two Functions*

In speaking of the future, the mind regards the now, which in reality has a twofold character of terminating the past and opening the future, in only one of its functions, namely, that as the principle of time to come. In considering the past, the mind considers only the function of the **now** as terminating the time that has been. In consider-

ing the present day, once more reason considers, at the beginning of the day, only the function of the now as a principle and at the end of the day only the function of the **now** as a term. Similarly in considering any period of time, past or future, the mind considers, first, only the opening function of the now that begins the period and, second, only the closing or terminating function of the now that ends it. **In abstracting for its consideration any portion of time, reason views the instant or now under only one of its two functions; reason considers the now either as terminating the past or as beginning the future. It cannot identify these two functions of the now.**[30]

The now is not the present. It is not even a part of time but rather a limit of time. It is related to time as a term is related to that which is terminated or as a principle is related to that which flows from it.[31] It divides and continues the temporally prior and the posterior, which are known first from the prior and posterior in a motion's trajectory. As that according to which motion is measured, the now determines the prior and posterior. The now is thus a kind of standard to determine what we are to take as prior and what as posterior in our numbering of motion and hence our determination of time.

VI. KINDS OF NUMBER

a. *Number as Something Primary*

Number is involved whenever we affirm or deny that one thing is greater or less than another in the physical world. To claim that **one** person is taller than another is to say that there are more units of measurement in the first than in the second. To think of an elephant as heavier than a mouse is again to refer to a difference in the number of weight units which each thing contains. In a similar way, we judge motion to be more or less complete by that peculiar kind of number which is time. Motion as corresponding to a prior part of its trajectory is complete, and as represented by the posterior part of its pathway is incomplete.

It should be stressed, however, that we are not measuring the prior and the posterior when we tell time; to measure prior and posterior parts of quantity is the task of a geometrician and the result is some sort of spatial measurement and not a determination of time. Time is a measurement of motion, not of the prior and the posterior in quantity. Rather than being a measure of the prior and the posterior, time

measures according to the prior and the posterior, and what it measures in this way is motion.

b. *Imprecise Number*

Unequipped with a watch or any other fairly precise timepiece, the mind naturally numbers motion according to priority and posteriority but only in an imprecise and highly approximate way. It may not use actual and explicit numbers. But it is implicitly and vaguely employing number, for otherwise it would not be aware that time is passing. It says this part of motion occurs first and that part at least second. The mind is aware of the parts of time which are determined by the parts of motion which in turn are determined according to the prior and the posterior in magnitude, and to be aware of parts is, at least in an implicit form, to number. Our clocks and chronometers do not abolish the mind's natural, if implicit, numbering of the parts of time. They refine and imitate it, like an art building on nature. We surely have to know what time is before we can make sense of the written numbers on a dial.

c. *Applied Number*

Number can have two senses. It may be pure or abstract number like ten or a dozen, or it may be applied or concrete number like ten teeth or a dozen eggs. Time is the second kind of number, because it is not a number abstracted from the thing numbered, but is a number existing, as it were, within the thing numbered. By analogy to the teeth or eggs which are numbered things, the concrete parts of motion are the realities measured by time.[32] If time were pure number, it would be strictly a mathematical reality rather than anything physical and natural. If this were so, time would apply to quantified substance but not to the qualities and motions which complete the structure of physical things. But time as a number measures the motions of quantified substances; it is not limited, as is arithmetical number, to quantified substance itself.[33] Time numbers or measures motion rather than the purely quantified, the simple prior and posterior of place and space. Time is the number of motion according to the prior and the posterior. In other words, time does not pertain to discrete (arithmetical) quantity, but to continuous (geometrical) quantity. The reason why this is so is that the reality, measured by time, namely motion, involves the continuum.

VII. THE MOBILE IN ITS MOTION IS MEASURED BY TIME

It is possible to demonstrate that the mobile, as subject of motion, is measured in its motions by time. Here is the causal (propter quid) demonstration:

That which is numbered according to prior and posterior in motion	is measured by time.
The mobile, as the subject of motion,	is numbered according to the prior and posterior in motion.
Therefore the mobile, as the subject of motion,	is measured by time.

The major proposition is evident from our definition of time, and the minor is clear from the fact that the mobile, in its motions, has a prior state (potency) and a posterior state (act) continuous with each other.

VIII. TIME AND REALITY

a. *Time and Rest*

Time is primarily a measure of motion, and what is prior and what is posterior in the parts covered by the motion are established by the now. What is at rest, like Gibraltar, is related to motion, since things are moving around it; hence, it can be measured by time.[34]

b. *Time and the Mind: A Question*

Time is rightly termed a kind of accident of motion;[35] but this does not help us greatly in determining the status of time. Is time real? Or is it, as Kant said, merely mental or logical? If time is a number and number depends on the human mind, it would seem as though, unless there were human intelligences, there could be no number of motion, there could be no time.

C. *Time and Reality*

It is true that time exists in its most perfect form in the intellect of man, and in this respect there is something to be said for Kant's

argument that time is only in our mind. But contrary to Kant's view, time outside the mind must have at least an imperfect existence.[36] It cannot be passed off merely as something we impose on the real by the structure of our mind.

Number itself has a foundation in reality, since there are countless things in the real world which the mind does not create but only knows by numbering them. The mind does not create the three of the clover leaves, but in numbering the leaves merely discovers how many there are.

Now it is true that there could be no actual enumeration of the parts of time if there were no human soul. Nevertheless, even if there were no human souls, there would still be a numerability in the prior and posterior parts of a motion's trajectory, and this, as we have seen, is the foundation for time. **To this extent at least, time has an imperfect existence outside tire mind. It has a foundation there.**

Another comparison might help. **Just as there would be no sensibility in things if nature did not intend animals that could sense — for the existence of the sensible as a potency that could never be actualized would be a contradiction[37] — so there would be no numerability in the parts of motion if nature did not intend in some way a human mind that could number the numerable and thus reduce the potency to a** state **of act.[38] To** the extent that the parts of motion are numerable, time is real; but to the extent that there is no actual numbering, time is only imperfectly real. Without the mind, motion itself would have only an imperfect existence, since the only actual existent in motion is an "indivisible"[39] corresponding to the "now" of time.

Time is thus neither in the mind nor outside of it, as Kant and Bergson argued in their extreme views. Time is a relation between the mind and motion. It is in the mind relating itself to motion, i.e., recognizing motion by numbering it.

IX. SUMMARY AND CONCLUSION

Our position thus steers a middle course between the extremisms of Kant and Bergson. Time is not motion but is related to motion. Time is the measure or number of motion according to the prior and the posterior. The prior and the posterior in our definition are known first from magnitude; and from magnitude we speak of the "parts" of motion. It is according to these parts that motion is measured and that time exists. Such a definition is presupposed by modern physics and other

modern sciences because it searches out what it is that we measure with our clocks and other instruments. Time is like a line; the **now** like a point. The **now** is not a part of time any more than a point is **part** of a line. The **now** is the divisor and continuator between the past **and** the future. The present is a synthesis of part of the past and part of the future.

Time has its perfect existence only in the mind; outside the mind, its existence is real but imperfect. Such existence is the foundation for time's existence in the mind.

REVIEW QUESTIONS

1. Name some of the difficulties in defining time.
2. Can time be defined by measuring it more precisely, as in modern science? Explain.
3. State the views of time as found in Kant and in Bergson.
4. Prove that time is not motion.
5. Show that time is never without motion.
6. From where do we get the idea for the prior and the posterior in discussing time? Explain.
7. Why is local motion usually chosen as a means of telling time?
8. Explain how local motion makes us aware of time.
9. Why is time a number?
10. Explain the likeness and difference between time and a line and between the now and a point.
11. What is the present?
12. Show that the now is not a part of time.
13. Explain the twofold function of the now.
14. What does reason do, with respect to the now, when it isolates for consideration a period of time?
15. What kind of number is time?
16. What things are in time? Explain.
17. Is time real or only mental? Explain, using the analogy of sensibility and sensation.

PROBLEMS

Explain and evaluate the following two passages:

I

"We must take this as our starting-point and try to discover — since we wish to know what time is — what exactly it has to do with movement.

"Now we perceive movement and time together: for even when it is dark and we are not being affected through the body, if any movement

takes place in the mind we at once suppose that some time also has elapsed; and not only that but also, when some time is thought to have passed, some movement also along with it seems to have taken place. Hence time is either movement or something that belongs to movement. Since then it is not movement, it must be the other.

"But what is moved is moved from something to something, and all magnitude is continuous. Therefore the movement goes with the magnitude. Because the magnitude is continuous, the movement too must be continuous, and if the movement, then the time; for the time that has passed is always thought to be in proportion to the movement.

"The distinction of 'prior' and 'posterior' holds primarily then, in place; and there in virtue of relative position. Since then 'prior' and 'posterior' hold in magnitude, they must hold also in movement, these corresponding to those. But also in time the distinction of 'prior' and 'posterior' must hold, for time and movement always correspond with each other. The 'prior' and 'posterior' in motion is identical in substratum with motion yet differs from it in definition, and is not identical with motion.

"But we apprehend time only when we have marked motion, marking it by 'prior' and posterior'; and it is only when we have perceived 'prior' and 'posterior' in motion that we say that time has elapsed. Now we mark them by judging that A and B are different, and that some third thing is intermediate to them. When we think of the extremes as different from the middle and the mind pronounces that the 'nows' are two, one before and one after, it is then that we say that there is time, and this that we say is time. For what is bounded by the 'now' is thought to be time — we may assume this.

"When, therefore, we perceive the 'now' as one, and neither as prior and posterior in a motion nor as an identity but in relation to a 'prior' and a 'posterior,' no time is thought to have elapsed, because there has been no motion either. On the other hand, when we do perceive a 'prior' and a 'posterior,' then we say that there is time, for time is just this — number of motion in respect of 'prior' and 'posterior.'

"Hence time is not movement, but only movement in so far as it admits of enumeration. A proof of this: we discriminate the more or the less by number, but more or less movement by time. Time then is a kind of number. (Number, we must note, is used in two senses — both of what is counted or the countable and also of that with which we count. Time obviously is what is counted, not that with which we count: these are different kinds of thing.)"

Aristotle, *Physics*[40]

II

"This result might have been foreseen by noticing that mechanics necessarily deals with equations, and that an algebraic equation always expresses something already done. Now, it is of the very essence of duration and motion, as they appear to our consciousness, to be something that is un-

ceasingly being done; thus algebra can represent the results gained at a certain moment of duration and the positions occupied by a certain moving body in space, but not duration and motion themselves. Mathematics may, indeed, increase the number of simultaneities and positions which it takes into consideration by making the intervals very small: it may even, by using the differential instead of the difference, show that it is possible to increase without limit the number of these intervals of duration. Nevertheless, however small the interval is supposed to be, it is the extremity of the interval at which mathematics always places itself. As for the interval itself, as for the duration and the motion, they are necessarily left out of the equation. The reason is that duration and motion are mental syntheses, and not objects; that, although the moving body occupies, one after the other, points on a line, motion itself has nothing to do with a line; and finally that, although the positions occupied by the moving body vary with the different moments of duration, though it even creates distinct moments by the mere fact of occupying different positions, duration properly so called has no moments which are identical or external to one another, being essentially heterogeneous, continuous, and with no analogy to number.

"It follows from this analysis that space alone is homogeneous, that objects in space form a discrete multiplicity, and that every discrete multiplicity is got by a process of unfolding in space. It also follows that there is neither duration nor even succession in space, if we give to these words the meaning in which consciousness takes them: each of the so-called successive states of the external world exists alone; their multiplicity is real only for a consciousness that can first retain them and then set them side by side by externalizing them in relation to one another."

Henri Bergson, Time and Free *Will*[4]

NOTES TO CHAPTER XVI

1. Confessions, Bk. XI, ch. 14.
2. Cf. Chapter XV, p. 297.
3. Cf. the introduction to the discussion of time in *The Great Ideas, A Syntopicon of the Great Books of the* Western World, in "Great Books of the Western World," II, 896.
4. Phys., Bk. IV, ch. 10, 218a, 4-8; Com. on the Phys., Bk. IV, les. 15, n. 1079.
5. Critique of Pure Reason, transi. N. Smith (New York, 1947), pp. 74-75.
6. Creative *Evolution,* transi. A. Mitchell, (New York, 1914), p. 317. Reprinted with permission of Henry Holt and Company.
7. *Ibid.,* p. 340.
8. *Ibid.,* pp. 340-341.
9. Timaeus, 37, transi. B. Jowett, II, 19; cf. the study of time in Plato, Aristotle, Plotinus, and Augustine in J. Callahan's Four Views of Time in the *Ancient World* (Chicago, 1948).
10. Phys., Bk. IV, ch. 10, 218b, 10-14; Com. on *the Phys.,* Bk. IV, les. 16, n. 1092.
11. Phys., Bk. IV, ch. 10, 218b, 14-19; Com. on *the Phys.,* Bk. IV, les. 16, n. 1093.
12. Com. on the *Phys.,* Bk. I, les. 2, n. 38.
13. Summa Theol., I, q. 10, a. 1.
14. Sum. cont. *Gent.,* Bk. I, ch. 55.
15. Phys., Bk. IV, ch. 11, 219a, 4; Com. on *the Phys.,* Bk. IV, les. 17, n. 1099; cf. time and successive acts of angels in Summa *Theol., I,* q. 53, a. 3; q. 63, a. 6, reply 4.

16. Phys., Bk. IV, ch. 11, 219a, 13-14; Com. on *the Phys.,* Bk. IV, les. 17, n. 1105.
17. Summa *Theol., I,* q. 7, a. 3.
18. Com. on *the Met.,* Bk. V, les. 15, n. 986.
19. Phys., Bk. IV, ch. 11, 219b, 9; Com. on the Phys., Bk. IV, les. 17, n. 1113; Com. on the *Met.,* Bk. XI, les. 10, n. 2354.
20. Com. on *the Phys.,* Bk. IV, les. 18, n. 1126.
21. *Ibid.,* les. 17, n. 1109.
22. *Phys.,* Bk. V, ch. 1, 220a, 24-25; Com. on the Phys., Bk. IV, les. 17, n. 1110; Summa Theol., I, q. 10, a. 1.
23. Summa Theol., I, q. 7, a. 3, reply 4.
24. Phys, Bk. IV, ch. 13, 222a, 14-16; Com. on the Phys, Bk. IV, les. 18, n. 1120.
25. Summa Theol, I, q. 10, a. 4, reply 2.
26. Sum. cont. Gent, Bk. II, ch. 36; Summa *Theol,* I, q. 10, a. 4, reply 2.
27. Phys, Bk. IV, ch. 11, 219b, 26-28; Com. on the Phys, Bk. IV, les. 18, n. 1117; Summa *Theol,* I, q. 10, a. 4, reply 2.
28. Com. on *the Phys,* Bk. IV, les. 19, n. 1139.
29. Ibid, Bk. IV, les. 18, n. 1150 ff.
30. Summa Theol, I, q. 10, a. 4.
31. On the Power of God, q. 3, a. 17, reply 5; q. 4, a. 2, reply 13.
32. Summa *Theol,* I, q. 10, a. 6; On the Power of God, q. 9, a. 5, reply 6.
33. Phys, Bk. IV, ch. 12, 220a, 26 (passim); Com. on the Phys, Bk. IV, les. 17, n. 1113.
34. On *the Power of God,* q. 5, a. 5, reply 10; Com. on the Phys, Bk. IV, les. 20, n. 1169.
35. Com. on *the Phys,* Bk. IV, les. 23, n. 1204.
36. *Ibid.,* n. 1212.
37. Sum. cont. Gent, Bk. II, ch. 22.
38. Phys, Bk. IV, ch. 14, 223a, 21-27; Com. on *the Phys, Bk. IV,* les. 23, nn. 1209-1210; cf. P. Conen, "Aristotle's Definition of Time," The New Scholasticism, XXVI (1952), 451 ff.
39. Com. on the Phys, Bk. IV, les. 23, n. 1211.
40. Bk. IV, ch. 11, 219a, 3-219b, 8; prior and posterior are substituted in the above passage for *before* and after.
41. *Time* and Free Will, transi. F. Pogson (London, 1910), pp. 119-121.

CHAPTER XVII

MOTION AND ITS KINDS

I. THE ESSENTIAL AND THE ACCIDENTAL

a. *Introduction*

Motion has now been defined; and, because its character, as we have shown, is finite, it can be measured. To recognize mobile being and motion is to measure them by place and time; to recognize place and time is to measure mobile being and motion. Having studied motion and its measures, we can turn now to the problem of dividing motion.

Motion can be divided in two ways: according to its various species or kinds, such as qualitative change and local motion; and according to its quantitative parts, such as halves, quarters, eighths, and so on.[1] The first kind of division will be discussed in the present chapter with the second kind deferred until Chapter XVIII. Our division of motion into its species or kinds can logically take place after our earlier consideration of motion in general. Such a division of motion into its parts will provide a context for more specialized investigations, like those in modern science, where details of all these initial divisions can be explored.

In dividing motion into its kinds, the first and most fundamental division is that between essential and accidental motion, and the basis for making this division can be one of three things: (1) the mobile being itself; (2) the mover; and (3) the terminus or term of the motion — the attained term which is the new form or the relinquished term which is the old form, i.e., the privation of the new one.[2]

b. *Essential and Accidental Motion in the Mobile Being Itself*

On the part of the movable reality, there may first of all be accidental

motion. For instance, when that which is red, e.g., an apple, falls to the ground, red undergoes local motion in an accidental way. Tire reason why the apple falls is not because it is red but because it is a body of a certain mass. The proper motion of the red as such is qualitative change. For the red to undergo local motion is accidental to its nature. Local motion of the red takes place not because of the essence of the red but because of the locally moving body with which the red happens to be associated.

On the part of the movable being, there are two types of essential motions: one type *of* essential movement refers to a part of the mobile being and the other refers to the whole of the mobile being. To say that an animal is healed because its leg is healed is to ascribe to the animal a motion that is proper only to one of its parts. A thing may therefore be moved in an essential way but only according to one of its parts. When a man dies, death is due not to what is primary and proper to man, namely his reason, nor is it due to his animal character. Man dies because he has a vegetative character. Tilings die not because they are human or even animal but because they are living. Death is essential to man, but only according to part of him (i.e., the vegetative part).

Our second division of essential motion on the part of the movable being is motion according to the whole of the thing in question, i.e., motion according to what is primary or specific to the thing,[3] When hydrogen and oxygen become water, they are changed not in an accidental way nor only according to their parts. Their whole beings are changed, and a whole new being results.

c. *Essential and Accidental Motion in the Mover*

On the part of the mover or agent, a twofold distinction must again be drawn between the accidental and the essential; and essential motion as characterizing the agent is again subdivided into what is primary and what is according to a part.

Accidental motion as relating to the agent may be illustrated by our familiar example of a musician building a house. The builder constructs a house as a builder and not as a musician. To identify the builder of a house as a musician is therefore to name what is only accidental to the motion of building.[4]

As in our previous division of the essential into what is according to whole and what is according to part, so here the motion of a mover

may be essential in two ways. **The motion of a mover may be essential,** but only according to a part of the agent, as when a man strikes a wall. Such efficient causality takes place only according to a part of the man, the hand, and hence the motion is essentially by the mover, the man, but only according to a part of him.

A second way in which motion may be essential on the part of a mover is to be essential according to the mover as a whole. Examples of such motions are a doctor healing the sick and living things reproducing themselves. It is up to specialized scientific investigation to give further examples of such primary and essential motion.

d. *Essential and Accidental Motion in the Terms*

On the part of its terms, motion again may be accidental or, in a twofold way, essential.6 Of the two terms of motion, the attained term (terminus ad quem) is the one that is of interest; the relinquished term (terminus a quo) is the result not of the motion now taking place but of some previous motion. When water is moved from container A to container B, the analysis of this motion does not require us to determine how the water got to container A. This is the result of a previous motion, not the motion that is of interest. Our principal focal point is the motion of the water to container B. We name any motion from its attained term, and hence it is this term that is of interest in explaining any motion. We speak, for instance, of the reddening of an apple, not of its de-greening. We speak of the growth of an animal, not its loss of littleness, of the setting of the sun, the fall of a body, the healing of the sick, the production of water. In all of these cases, as in our example of the local motion of water from A to B, we are referring motion to its acquired term rather than its relinquished one, the term whereto rather than the term wherefrom.6

Nor is this only a manner of speaking. For any motion that takes place has a certain repugnance to its relinquished term. It has a suitability or compatibility to the attained term as imperfect act in reference to perfect act. An apple can become red only to the extent that the "old" green has gone out of existence. The reddening motion is repugnant to the old form. In a kindred way, a body can fall only insofar as its former height is lost. Hence the motion of anything is incompatible with the continued existence of the old form. It is no mere accident of language, then, to name motion from its acquired term. Our naming parallels tire very nature of motion's principles.7 The attained form is

the principle of organization in the knowing of any motion because it is the principle of organization in things themselves.[8] It is, we have seen, the cause of causes.

If something becomes green and also becomes edible, the consequent edibility is purely accidental to the green itself, since many things can become green without ever becoming edible, at least edible for man. Color is involved in the seeing of things, not in the digesting of them. The color of a thing and its being edible may thus be only accidentally related when we consider a motion according to its term.

To say that a thing, on becoming green, acquires a color is to name only a generic part of the new form, the color, whereas a more proper designation would have to include the other and more specific part of the attained term, the green. To say that a thing in becoming green becomes colored is to name a motion from what is essential on the part of the term but only according to part of that term, the general part or genus.

On the part of the term, it is possible to name the essential and primary product of a motion; such would be the case when the form of an oak tree emerges from the acorn. Precisely as oak, the oak tree in a primary and essential way is the term of the acorn's motion.

In scientific knowledge, the mind is concerned with what is essential; it is not concerned with the accidental. The accidental is the indeterminate, i.e., it lacks a determinate relationship with the motion® under way, whether we are looking at the accidental in the mobile thing, in the mover, or in the term of the motion. In perfect scientific knowledge of any change, it is necessary to know not only what is essential but what is proper or primary.

II. DIVISION OF CHANGE

a. Four *Possible Ways of Changing*

Our definition of motion in Chapter XIII took motion in a wide sense of the word so as to include even substantial change.[10] In fact, so far throughout this book, motion has been used as synonymous with all types of change. It is time now to draw a distinction between motion and other kinds of change which are not motion in the strict sense.

In order to establish a framework for this distinction, it will be helpful to list four possible ways of characterizing change by comparing its beginning to its end.[11]

1. Both terms of the change may be positive: a little dog becomes a big dog.

2. The change may proceed from a positive term to a negative one. When a tree dies, it goes out of existence, and it is proper to speak of a movement from being to non-being.

3. Tire change may go from a negative term to a positive one. After an animal is born, it can be said that what did not exist at some previous time now exists. Here the change is from non-being to being.

4. Merely logical considerations would permit the naming of a fourth case where there would be a movement from negation to negation; but since there is no physical movement that could take place in this way, we need not consider this fourth alternative.

b. *Motion Proper*

The change from one positive state to another positive state is motion in the strict sense.[12] In such cases, non-being is involved at neither end of the process. Rather at both ends there is an actualized subject which we have previously called second matter. When an animal is born, as in our third case above, it is said to come to be in an absolute way. But as the animal grows, it can no longer be said to come to be in an unqualified way, that is, to come from not being an actualized subject to being such a subject. Rather the animal after birth is said to come to be in a qualified way, i.e., to become tall or adult or feathered or hairy or whatever else may be of interest in our study of the animal. When an animal is produced or generated, absolute becoming is involved; when an animal grows or acquires some other characteristic, only relative becoming is involved. And it is this relative becoming which is motion in the strict sense. Change is a wider term than motion and includes the two other cases listed above.

C. *Generation and Corruption*

The process from non-being to being is called generation.[13] Such a change can be seen in the production of a new living individual from matter supplied by parents. The term generation is taken, in fact, from biological reproduction.[14] But generation occurs also in the non-living world as is illustrated by the formation of ashes when paper is burned or by making water from hydrogen and oxygen. This is our third case listed above.

The opposite to generation is corruption or destruction, a change from being to non-being.[15] An example of such a change is death, but once again the process we are describing is not restricted to the living world. In making water from the matter of hydrogen and oxygen, the hydrogen and oxygen are corrupted; in the burning of paper, the cellulose in the paper is destroyed. This is our second case listed above.

Generation and corruption may each be of two types: simple or absolute generation and simple or absolute corruption; and relative or qualified generation and relative or qualified corruption.[10] Absolute generation and absolute corruption are substantial changes which occur between contradictory terms in the order of substance, the being and non-being of whatever is involved. Qualified generation and qualified corruption are changes between contradictory terms in the order of quality, as when what is non-white becomes white or what is sour becomes non-sour. As our examples indicate, this qualified generation or corruption has contradictory terms, white and its contradictory opposite, non-sour and its contradictory opposite. But for purposes of this introductory book, qualified generation and qualified corruption, which take place at the indivisible terminations[17] of motion in the proper sense, will not be treated further here. Hence, unless otherwise indicated, generation and corruption will be considered throughout the following pages only in their simple or absolute character as substantial changes. In our context then, generation and corruption are changes between being and non-being in the order of substantial reality.

Observation reveals that the generation of one mobile being always entails the corruption of some other mobile being.[18] The burning of paper under one aspect is the generation of ashes and under another aspect the corruption of paper. The change is one in reality but twofold in its relations, just as the ascent and descent of a mountain pathway.[19] That the generation of one reality involves the corruption of another is true whether there is an absolute or substantial coming to be and passing away or whether the change is only in quality. However, although a generation and a corresponding corruption take place simultaneously and are not separate from each other, they are really distinct changes, as our definitions indicate. Generation and corruption, though one in reality, are really distinct because each has a distinct relation to a different term.

III. SUBSTANTIAL AND ACCIDENTAL CHANGES COMPARED

a. *Contradiction and Contrariety*

In addition to change from a negative to an affirmative pole and vice versa, there is a third alternative in which both terms of the change are positive. Here there is change not according to contradiction but according to contrariety:[20] a thing changes from being young to being old, from being little to being big, from being black to being white, from being here in the local order to being there.

Generation and corruption, in the light of our previous restrictions, are substantial changes because in such processes a whole new substance — a horse, a tree, or water — comes into existence, or a whole new substance — a horse, a tree, or water — goes out of existence. The third kind of change is called accidental change because, although the substance abides throughout the change, a new accidental form — such as a color, a size, or a place — is acquired.

b. *in Generation and Corruption Matter Is Not Subject to Motion*

Generation, corruption, and accidental changes are all changes, but only accidental change is motion in the strict sense. Generation and corruption are therefore changes but not motion, while accidental modifications are a type of change which is also motion.[21] This distinction must now be established, and, for the sake of economy, it will be argued below only that generation is not a motion. The reader may supply a similar argument for the case of corruption. Tire demonstration to prove that generation is not a motion consists in showing that the matter of generation is not a subject of motion.[22]

> What does not exist as a definite something is not subject to motion.
> But the matter of generation (prime matter) is that which does not exist as a definite something.
> Therefore, the matter of generation is not subject to motion.

In order to understand this syllogism, we must recognize that motion, in the strict sense, takes place within a subject. This was implied by our second definition of motion as the "act of the mobile precisely as such."[23] It is impossible, however, for anything to take place in what is not a definite something, and primary matter, as we have seen, is purely indeterminate. There can be no imperfect act in primary matter

because substantial form is the first act of such matter and there can be no act, even an imperfect one, until this first act is realized. Previous to their absolute existence, things cannot undergo motion. Since the matter subject to generation is purely indeterminate, a mere potency to existence, it cannot be imperfectly in act through motion unless its pure potencies are first actualized by substantial form, a first and perfect act,[24] to make a complete substance.

c. *Substantial Change Not Gradual*

Motion always involves time; generation and corruption, on the contrary, are not gradual. They are instantaneous.[25] Motion is necessary in order to dispose the old substance for corruption and to prepare the matter so that a new substantial form, which will make it a new being, can emerge. But when the motion has gone sufficiently far, generation and corruption take place instantaneously. A sick person gradually loses his vitality; but death, wherever it occurs, takes place instantaneously. There is no such thing as a being half living and half dead. If there is any life left in a dying thing, it is still living, and what is dead is dead.

d. *Motions Reveal Substantial Change*

Motion, in its most proper sense, always takes place in a substance.[20] It is always an accidental, rather than a substantial, change.

It is now possible to propose that when the object of our science is designated as mobile being, mobile or motion is taken in its strictest sense as accidental in character. At least this is our primary meaning of mobile. It is mobile being, being capable of accidental change, that first meets our senses; it is by observing differences in accidental motions that we know substantial changes have taken place. Accidental changes are the light by which we know substantial change. Thus, ashes have a set of mobile properties in the accidental order which are quite different from the set of mobile properties in paper. The mind is therefore justified in concluding that there is a different principle or substance underlying the accidents in each of the two cases and that therefore there is a substantial change when paper burns. In this fashion, the motions of things lead us to a knowledge of substances, and the different sets of motions at the beginning and end of a process enable us to conclude that substantial change has occurred. The motions of things are directly observable to our senses. It is with motion that our knowledge of nature

begins and it is in motion also that our knowledge of nature is always checked. What is most properly the object of our science is mobile being, where motion is taken in its strict sense;[27] and through such motion we know other types of change.

IV. CATEGORIES SUBJECT TO MOTION

a. *The Posing of Our Question*

Our discussion thus far has led us to the conclusion that there are three kinds of change: generation, corruption, and motion. It is now proper to make some subdivisions within motion itself, and no better reference can be found for such a process than to compare motion once more to the categories. **Motion, it was previously said, is reducible to the category in which it is taking place. What are these categories in which** motion **takes place?** Our knowledge of logic should remind us that there are ten categories: substance, the quantified, the qualified, to be related, to be situated, when, where, to be clothed (equipped), to act, and to receive.[28]

b. *Elimination of Some Categories*

Let us eliminate some of these categories right away. **Time must remain constant throughout motion; only if time is constant and unchanging can a meaning be attached to expressions like fast or slow motion.** If, for example, time were speeded up while a moving body correspondingly increased its velocity, the mind would **be unaware** that the body was moving faster than before. Hence the category **when** is not subject to motion.

To be situated is to have a certain order of parts in a whole; since order is a relation, we can determine whether there is motion in the category of ***being situated*** by asking whether motion occurs in the category of being related. To be clothed or equipped is also a special manner of being related and the question of whether motion takes place in the category of ***being clothed*** will be answered in the same way as the question of whether motion occurs in the category of being ***Telated.*** Hence it remains for us to decide whether motion takes place in substance, in being quantified, in being qualified, in being related, in where, in acting, and in being acted upon.

Motion is a gradual and continuous process between two positive

poles. The new form and its previous opposite are contraries in the strict sense of the term, i.e., they are positive poles of the same genus with a certain distance between them.[29]

Enough has already been said to argue that there is no motion in substance but only generation or corruption. Substantial changes are instantaneous; even though a piece of paper may be gradually burned, whatever part is actually being corrupted is instantaneously changed into something besides paper. Generation and corruption, it was seen, are changes but not motions.

c. *Where Motion Occurs*

Motion in the proper sense does take place in quantity, quality, and place.[30] Animals and plants have a certain minimum quantity when they begin to exist as individual members of their species; and they gradually attain a greater quantity until they reach a maximum size. Such a motion is called growth. An opposite motion in the order of quantity, shrinkage or diminution, is a loss of size in living things. There are thus two motions in the order of the quantified. Tire so-called growth of crystals is not growth, properly speaking, but local motion. In non-living things, "growth" is merely the addition of exterior parts. It is not one motion having a single definite goal like a definite or determinate quantity, e.g., the figure of a man.

In sensible qualities like color, taste, etc., there are also motions because there are two positive poles between which a change can take place in a gradual and continuous manner. Other common changes in sensible quality are intensification, as when something becomes more red or sweet, and remission, as when something becomes less red and less sweet. All changes in the order of sensible quality are called alterations; they are either simple alteration or intensification and remission.[31]

Finally, in the order of place there is contrariety in the strict sense, and the kind of change we find here is called local motion.

There are thus three species of change: generation, corruption, and motion;[32] generation and corruption are changes but not motions; growth and diminution, alteration, and local motion are changes and also motions.

d. *The Other Categories*

Motion does not take place in the category of being related and hence it does not take place in tire categories of ***being situated*** and of

being clothed. A simple example of apparent motion in relation would be the change to an equality in size between two cows, one of which has previously possessed a certain weight while the other grows up to attain the same weight. Can the relation of equality in weight between the animals come to be and pass away by motion?

The answer is in the negative.[33] The first cow, prior to the growth of the second, had within itself the foundation for being related, as equal, to all things of the same weight, and nothing new takes place in the first cow when the second cow grows up to the same size so that the two cows are equal in weight. In a similar way, what happens in the second cow is growth to a certain size or weight, the foundation for that relation of equality between the second cow and the first. Motions occur in the foundations of the two relations, e.g., in size (quantity), but not in the relations themselves. This conclusion can be reached in a much more positive way by showing that relations never appear gradually but all at once. The cows in our example are related as equals in weight as soon as the second cow reaches the size of the first. But there is no gradual coming to be of the equality. The second cow was not at first less equal to the first and it did not, as it grew, become more equal. Relations appear instantaneously. Motion is involved in the foundations of relations like, for instance, equality, i.e., there is the motion called growth on the part of the second cow. But there is no motion in the relation as such.

With the ruling out of substance, when, being related, being situated, and being clothed as categories within which there is motion and with the ruling in of motion in quantity, quality, and place, it remains now to ask whether there is motion in action and in passion. As our previous analysis revealed, both action and passion are motions with differing relations in each case. Action is motion as by an agent out of or from a patient; and passion is motion as out of the patient by an agent. But there is no motion in either of these categories. If action and passion are both motion, to propose that there is motion in action and in passion would be saying that there is motion in motion. This is an absurd position. Were it tenable, we would have to find a subject and a form for the motion taking place in motion; and we would still be left asking whether there is motion in motion in motion, etc.[34]

e. *Summary*

So far, then, we have identified changes in the category of substance,

where there is generation and corruption, and changes in the categories of quantity, quality, and place, where there is motion in the proper sense of the word. Generation is the change from non-being to being and corruption from being to non-being. Motion within the category of quantity is growth and diminution or shrinkage. Motion in the category of the qualified is alteration. Motion in the category of place is called local motion.

Growth and diminution apply only to the living world. Growth is the motion from a smaller size to a larger one, and diminution is the opposite. The mechanical addition of parts, as in the making of a house, is not growth but merely a local motion of the bricks. Tire same is true in the so-called growth of crystals. A house is not one thing but many things, and so is a crystal formation if it is merely a mechanical addition of substances. True growth is an increase of quantity in the same substance, e.g., a tree or a dog.

Alteration, which is motion in the category of the sensible quality, may be simple alteration as in the change from black to white; or it may be intensification or remission, the motion to a greater or lesser rooting (radicatio) of a quality in a subject, e.g., the motion of a subject to a greater or lesser possession of a particular color like red.

There are thus three species of change: generation, corruption, and motion (i.e., alteration, growth, diminution, and local motion).

V. KINDS OF BEING IMMOBILE

As there are various ways in which things can change, so there are different ways in which a thing may be immobile.[35] In the first place, what is not in any way subject to change, i.e., the First and Unmoved Mover, is immobile. The Prime Mover transcends the whole order of motion and of mobility. Second, that which can be moved only with the greatest difficulty or that which it is not practical to move is also called immobile; for instance, a huge rock relative to the efforts of a single man is called immobile. Finally, something may be said to be immobile when it is capable of being moved but is not actually in motion. A stone perched on a mountaintop may be said to be immobile in this sense. Such an immobility is called rest, and a body in such an immobile stature is said to be at rest.

VI. THE UNITY OF MOTION

a. *Three Kinds of Unity*

In a chapter devoted to the division of motion and the comparison of motions with each other, it will be instructive to ask about the several ways in which motion may be one and the several ways in which motions may be diverse among themselves.[36] **Motions may be generically one,** as when they belong to the same category, i.e., to the same supreme genus. Thus, all local motion would be generically one. **Motion may** also be specifically one, as when their terms belong to the same species. Reddening is specifically alike in the case of apples; and so are all cases of growth among a given species of plant or animal. A third way in which **motion may be one is in the unity of number.** Motion has a numerical unity when there is a same subject which is moved, the same genus and species of motion, and the same time. The unity of motion in a billiard ball being rolled across the table is a numerical unity. To affirm that a motion is numerically one is to refer to the same individual motion. What this means shall now be explained.

b. *Three Conditions of Numerical Unity*

If a motion is to be numerically or individually one, it is clear that the same subject must be **involved throughout.** Thus the motion of a billiard ball across a table must involve the same billiard ball if numerical unity is to be existing in the motion; the motions of two billiard balls even through the same trajectory would be specifically alike but not numerically or individually one.[37]

For numerical unity, moreover, the motion of a given subject must possess a unity of species. In a plant that is changing color while swinging in the wind, there are at least two movements, alteration and local motion. The two movements have the same subject; but each motion has its own unity which makes it specifically and even generically different from the other. The subject and the alteration go to make up one motion; the subject and the local motion constitute the other change.[38]

Besides requiring a unity of subject and of species, the numerical unity of a motion demands that there be a unity of time. If a billiard ball is stopped in the course of its motion across the table and then started again, there are two different motions involved because there are two different times. A billiard ball going through exactly the same trajectory

as at a previous time would also lack individual unity in the relation of the two motions. Each motion has the same species and the same subject; but they differ as to the times of their occurrence. The numerical unity of a motion therefore requires a unity of time.[38]

As motion can be generically, specifically, and numerically one, so motions can be generically, specifically, and numerically different.

VII. CONTRARIETY OF MOTION

a. *Five Possibilities*

There are several possible ways in which motions may be contrary to each other. Tírese can be listed and then compared:

1. Two motions might be said to be contrary to each other when one approaches the same term and the other recedes from it. Thus, motion toward health is contrary to motion away from health.

2. Two motions might also be called contrary because of the contrariety of their relinquished terms. Thus motion from health is contrary to motion from sickness.

3. Two motions might also be called contrary because of the contrariety of their attained terms. Thus, motion to health is contrary to motion to sickness.

4. Two motions might also be called contrary because of the contrariety of the attained term to the relinquished term. Thus motion to sickness would be contrary to motion from health.

5. A fifth possibility for calling motions contrary would be the case of contrariety on the part of both terms, as motion from health to disease would be contrary to motion from disease to health.[40]

b. *Elimination of Some Possibilities*

Of these five possible ways of characterizing contrary motions, the fourth can be dismissed at once. Motion to sickness and motion from health is one and the same motion, and no motion can be contrary to itself.

The second possibility can likewise be left aside. Motions are not contrary because of the contrariety of their relinquished terms. If they were, two local motions that started with different relinquished terms and arrived at the same place would have to be called contrary. But when two motions go from different places to the same term, their

differences are rather removed than established, and such motions therefore cannot be contrary to each other.

Our first possibility does not express contrariety as well as the third and fifth cases we have listed. For motions are contrary much more by reason of their attained terms than by reason of their relinquished terms, and our first case mentions a relinquished term.41

c. *True Cases of Contrariety*

Motions, therefore, may be characterized as contrary in the light of our third possibility. For motion takes its species from its attained term, and hence two motions with contrary attained terms would be contrary. **But our fifth mode, where the relinquished terms are contrary as well as the attained terms, designates the contrariety of motion more completely, and motions of this fifth kind are more perfectly contrary to each other than motions which may have the contrary attained terms but similar relinquished terms.42**

In changes that are not motion, i.e., the substantial changes called generation and corruption, the contrariety cannot be taken from the contrariety of the attained and the relinquished terms; for such terms are not contrary but contradictory. Hence, contrariety, insofar as it exists, is taken from the approach or recession with respect to the same term.43 Thus, the generation of an animal is contrary to its corruption because of the approach to, or recession from, the same term, i.e., the being of the animal.

VIII. CONTRARIETY OF REST

Rest also involves contrariety. But not all rest is contrary to all motion.44 Thus, rest in the order of place is contrary to local motion, but it is **not** contrary to alteration or to growth. **Rest is contrary only to the species of motion to which it is related. Moreover, motion from** a relinquished term is contrary to rest in that term; but it is not contrary to rest in the attained term to which it tends and with which it has an affinity rather than a contrariety.45 Motion from white to black is contrary to rest in white. Motion away from the earth on the part of a body near the earth is contrary to rest on the earth.

Two cases of rest are contrary to each other when the terms with which the rest is associated are contrary.46 Thus, rest in health is contrary to rest in disease.

Generation does not have a contrary state of rest, and neither does corruption.[47]

IX. SUMMARY AND CONCLUSION

The burden of the present chapter has been the division of motion into its subjective parts where motions are compared and interrelated. Considered from the viewpoint of the movable thing, the mover, or the terms, motion may be either accidental or essential and, if essential, according to a part or according to the whole.

Processes in nature may go from negative to positive poles or vice versa; or they may take place between poles that are both positive. The change from negative to positive pole is called generation, and the opposite change is called corruption; generation and corruption may be relative as in accidental change or absolute as in substantial change. For purposes of this book accidental change will be considered not insofar as it is generation and corruption but insofar as it is motion. Motion is that type of change which occurs between two affirmative terms; motion takes place in three categories, quantity, quality, and place, and is of four types, growth, diminution, alteration, and local motion.

Substantial change, when it occurs, is always instantaneous; motion, on the other hand, is gradual and successive.

Motion does not take place in substance nor in time nor in any of the categories involving relation nor in action and passion. It occurs only in quantity, quality, and place.

As there are different ways in which a thing may change, so there are various ways in which a thing may be immobile. The kind of immobility which is of common interest to the science of nature is rest, the state of a thing which is capable of being moved but is not now undergoing motion.

Motion may be generically, specifically, or numerically one. As to the differences among motions, contrariety is always taken from the attained term. But the most perfect contrariety exists between those motions whose relinquished terms are contrary to each other and whose attained terms are also contrary to each other.

The divisions we have made throughout this chapter provide a perspective for more specialized investigations into nature. That is why such divisions are valuable. All of them are based upon experience more common and more general than the precise inquiries of science in the modern sense of the term, and they will enable the specialist to know what it

is that he is investigating. They will enable him to see his results in a proper context.

REVIEW QUESTIONS

1. In what two general ways can motion be divided?
2. Differentiate between the essential and the accidental and within the essential between the essential according to a whole and according to a part.
3. Apply these distinctions to the mobile, the mover, and the terms of motion, giving examples in each case of what is accidental and what is essential both according to a whole and according to part.
4. What are the three ways of characterizing change according to its terms as being positive or negative?
5. What is the difference between motion and other changes?
6. Differentiate between two types of generation and two types of corruption.
7. Explain the differences between change according to contradiction and change according to contrariety.
8. Show how primary matter is not subject to motion.
9. How does this show that substantial changes are instantaneous?
10. How do we detect that substantial changes have occurred?
11. Show by a process of elimination that only quantity, quality, and place among the categories are subject to motion.
12. Explain the motions which take place in these categories.
13. Name three ways in which a thing may be said to be immobile.
14. What three types of unity may a motion possess?
15. What is necessary that a motion be numerically one?
16. Explain what is necessary that motion be truly contrary.
17. To what kind of motion is the state of rest said to be contrary?
18. How does contrariety exist in regard to changes whose terms are contradictories?

PROBLEMS

Explain the following three passages:

I

"Everything which changes does so in one of three senses. It may change (1) accidentally, as for instance when we say that something musical walks, that which walks being something in which aptitude for music is an *accident*. Again (2) a thing is said without qualification to change because *something belonging to it* changes, i.e., in statements which refer to part of the thing in question: thus the body is restored to health because the eye or the chest, that is to say a part of the whole body, is restored to health. And above all there is (3) the case of a thing which is in motion

neither accidentally nor in respect of something else belonging to it, but in virtue of being *itself* directly in motion. Here we have a thing which is essentially movable: and that which is so is a different thing according to the particular variety of motion: for instance it may be a thing capable of alteration: and within the sphere of alteration it is again a different thing according as it is capable of being restored to health or capable of being heated. And there are the same distinctions in the case of the mover: (1) one thing causes motion accidentally, (2) another partially (because something belonging to it causes motion), (3) another of itself directly, as, for instance, the physician heals, the hand strikes. We have, then, the following factors: (a) on the one hand that which directly causes motion, and (b) on the other hand that which is in motion: further, we have (c) that in which motion takes place, namely time, and (distinct from these three) (d) that from which and (e) that to which it proceeds: for every motion proceeds from something and to something, that which is directly in motion being distinct from that to which it is in motion and that from which it is in motion: for instance, we may take the three things 'wood,' 'hot,' and 'cold,' of which the first is that which is in motion, the second is that to which the motion proceeds, and the third is that from which it proceeds. This being so, it is clear that the motion is in the wood, not in its form: for the motion is neither caused nor experienced by the form or the place or the quantity. So we are left with a mover, a moved, and a goal of motion. I do not include the starting-point of motion: for it is the goal rather than the starting-point of motion that gives its name to a particular process of change. Thus 'perishing' is change *to not-being*, though it is also true that that which perishes changes *from being:* and 'becoming' is change to being, though it is also change *from not-being.*"

Aristotle, *Physics*™

II

"Since, then, motion can belong neither to Being [substance] nor to Relation nor to Agent and Patient, it remains that there can be motion only in respect of Quality, Quantity, and Place: for with each of these we have a pair of contraries. Motion in respect of Quality let us call alteration, a general designation that is used to include both contraries: and by Quality I do not here mean a property of substance (in that sense that which constitutes a specific distinction is a quality) but a passive quality in virtue of which a thing is said to be acted on or to be incapable of being acted on. Motion in respect of Quantity has no name that includes both contraries, but it is called increase or decrease according as one or the other is designated: that is to say motion in the direction of complete magnitude is increase, motion in the contrary direction is decrease. Motion in respect of Place has no name either general or particular: but we may designate it by the general name of locomotion, though strictly the term

'locomotion' is applicable to things that change their place only when they have not the power to come to a stand, and to things that do not move *themselves* locally.

"Change within the same kind from a lesser to a greater or from a greater to a lesser degree is alteration: for it is motion either from a contrary or to a contrary, whether in an unqualified or in a qualified sense: for change to a lesser degree of a quality will be called change to the contrary of that quality, and change to a greater degree of a quality will be regarded as change from the contrary of that quality to the quality itself. It makes no difference whether the change be qualified or unqualified, except that in the former case the contraries will have to be contrary to one another only in a qualified sense: and a thing's possessing a quality in a greater or in a lesser degree means the presence or absence in it of more or less of the opposite quality. It is now clear, then that there are only these three kinds of motion."

Aristotle, Physics[49]

III

"It is true that then we say that a body is at rest we use a form of words which appears to assert something about that body considered in itself, and we might imagine that the velocity of another body, if reckoned with respect to a body at rest, would be its true and only absolute velocity. But the phrase 'at rest' means in ordinary language 'having no velocity with respect to that on which the body stands,' as, for instance, the surface of the earth or the deck of a ship. It cannot be made to mean more than this.

"It is therefore unscientific to distinguish between rest and motion, as between two different states of a body in itself, since it is impossible to speak of a body being at rest or in motion except with reference, expressed or implied, to some other body."

James Clerk Maxwell, Matter and Motion[50]

NOTES TO CHAPTER XVII

1. Com. on *the Phys.,* Bk. V, les. 1, 1236.
2. Phys., Bk. IV, ch. 1, 224a, 21-224b, 6; Com. on *the Phys.,* Bk. V, les. 1, n. 1236; Com. on *the Met.,* Bk. XI, les. 11, nn. 2355-2363.
3. What is primary (primo) is the "commensurate universal"; cf. *Exposition ot the Post.* Anal., Bk. I, les. **9, 11;** cf. also, Summa *Theol., I,* q. 8, a. 4.
4. **Cf,, for instance, Prin. of Nat-, 39;** Com. on the Phys., Bk. V, les. 1, n. 1239; Com. on *the Met.,* Bk. XI, les. 11, nn. 2358-2360.
5. *Phys.,* Bk. V, 224b, 16 ff.; Com. on the Phys., Bk. V, les. 1, n. 1240 ff.; Com. on the *Met.,* Bk. XI, les. 11, n. 2363.
6. Com. on the *Phys.,* Bk. V, les. 1, n. 1244; Summa *Theol.,* I, q. 45, a. 2, reply 2.
7. Summa *Theol.,* I, q. 45, a. 2, reply 2.

8. Com. on the *Met.,* Bk. II, les. 4, n. 320.
9. Ibid., Bk. IV, les. 1, n. 531; Bk. VI, les. 2, nn. 1172-1176.
10. Com. on the Phys., Bk. V, les. 2, n. 1254; cf. supra, Chapter XIII, p. 259.
11. Phys., Bk. V, ch. 1, 225a, 1-11; Com. on the *Phys.,* Bk. V, les. 2, n. 1255; Com. on *the Met.,* Bk. XI, les. 11, n. 2364.
12. *Phys.,* Bk. V, ch. 1, 225b, 1-2; Com. on *the Phys.,* Bk. V, les. 2, n. 1269; Com. on *the Met.,* Bk. XI, les. 11, n. 2375.
13. Phys., Bk. V, ch. 1, 225a, 13-14; Com. on the *Phys.,* Bk. V, les. 2, n. 1260.
14. Summa *TheoL,* I, q. 27, a. 2.
15. Phys., Bk. V, ch. 1, 225a, 17-19; Com. on the *Phys.,* Bk. V, les. 2, n. 1263.
16. *Prin. of Nat.,* 7; Com. on the Met., Bk. XI, les. 11, nn. 2366-2367.
17. Com. on the Phys., Bk. I, les. 13, n. 235.
18. Summa TheoL, I, q. 118, a. 3, reply 2; Com. on On Gen., Bk. I, les. 9; Com. on *the Met.,* Bk. II, les. 3, n. 313.
19. There is a distinction between "coming to be of white" and "destruction of non-white," On Truth, q. 28, a. 6.
20. Com. on the Phys., Bk. V, les. 2, n. 1269.
21. On *the Power* of God, q. 3, a. 2.
22. Com. on the Phys., Bk. V, les. 2, nn. 1264-1266; Com. on *the Met.,* Bk. XI, les. 11, nn. 2368-2373.
23. Supra, Chapter XIII, p. 263. Cf. St. Thomas' description of this second definition in the Disputed *Question: On the Soul,* transi. J. Rowan, q. 1, reply 15.
24. Com. on the *Phys.,* Bk. III, les. 2, n. 559.
25. Cf., for a discussion of instantaneous change, C. De Koninck, "Un paradoxe du devenir par contradiction," Laval *Théologique et Philosophique,* XII (1956), 9-51.
26. Com. on the Phys., Bk. V, les. 2, n. 1269.
27. Cf. Cajetan, De Subjecto Philosophiae *Naturalis.*
28. Aristotle, Categories, Bk. 1, ch. 4, Ib, 24–2a, 1.
29. Com. on *the Phys.,* Bk. V, les. 4, n. 1314; Com. on the Met., Bk. XI, les. 12, n. 2376.
30. Com. on the Met., Bk. XI, les. 12, n. 2376.
31. Phys., Bk. V, ch. 2, 226b, 1-9; Com. on the *Phys.,* Bk. V, les. 4, n. 1321.
32. *Com. on the Phys.,* Bk. I, les. 13, n. 234; Com. on the *Met.,* Bk. XI, les. 11, n. 2365.
33. Phys, Bk. V, ch. 2; 225b, 11; Com. on the *Phys.,* Bk. V, les. 3, n. 1287 ff.; On *the Power of God,* q. 7, a. 8, body and reply 5.
34. *Phys.,* Bk. V, ch. 2, 225b, 15-16; Com. on the Phys, Bk. V, les. 3, n. 1293 ff.
35. *Phys.,* Bk. V, ch. 2, 226b, 10-17; Com. on the Phys, Bk. V, les. 4, nn. 1325-1326; Com. on the Met, Bk. XI, les. 12, nn. 2401-2403.
36. Phys, Bk. V, ch. 4, 227b ff.; Com. on the Phys, Bk. V, les. 6, nn. 1351–1358.
37. Phys, Bk. V, ch. 4, 227b, 22-30; Com. on the Phys, Bk. V, les. 6, n. 1359 ff.
38. Com. on the Phys, Bk. V, les. 7, n. 1386.
39. Phys, Bk. V, ch. 4, 228a, 3-18; Com. on the Phys, Bk. V, les. 7, n. 1374.
40. Phys, Bk. V, ch. 5, 229a, 7 ff.; Com. on the Phys, Bk. V, les. 1, nn. 1387–1402; John of St. Thomas, Curs. Phil, II, Phil. Nat. P.I, q. XIX, a. 5.
41. Com. on *the Phys,* Bk. V, les. 8, nn. 1400-1402.
42. Phys, Bk. V, ch. 5, 229b, 20-23; Com. on the Phys, Bk. V, les. 8, n. 1402.
43. Summa *TheoL,* I–II, q. 23, a. 2; Com. on the Phys, Bk. V, les. 8, n. 1408.
44. Phys, Bk. V, ch. 6 (passim); Com. on the Phys, Bk. V, les. 9, n. 1412 ff.
45. Com. on the Phys, Bk. V, les. 1, n. 1244; Summa TheoL, I, q. 45, a. 2, reply 2.
46. Com. on the Phys, Bk. V, les. 9, n. 1415.
47. Ibid, n. 1423.
48. Bk. V, ch. 1, 224a, 21-224b, 9.
49. Bk. V, ch. 2, 226a, 23-226b, 9.
50. New York, n.d, p. 22.

CHAPTER XVIII

MOTION AND ITS PARTS

I. EVERY MOBILE BEING IS A BODY: A DEMONSTRATION

There are two ways of dividing motion. One is to divide motion into its species. This was the task of our last chapter. The other is to divide motion into its quantitative parts. And the reason why it belongs to the science of nature to discuss quantitative parts is that every mobile being is a body, and a body, by definition, is a substance endowed with quantity. Unless everything mobile were corporeal, it would not have a gradual character with prior and posterior parts. Hence, it is not proper to designate the object of our science as material or corporeal being. We have to demonstrate that the mobile is material or corporeal.

We can demonstrate that every mobile being is a body by the following syllogism:

> Whatever is composed of parts is a body.
> But every mobile being is composed of parts.
> Therefore, every mobile being is a body.

The major proposition is the definition of a body, and the minor is evident from our definition of motion. What is in motion is partly in act and partly in potency. Hence everything mobile must have at least two parts; it must thus be quantitative. Our present chapter asks about the number of these parts. How many parts are there in a body or a mobile being? This is the problem of the continuum, and in treating it we will have to repeat some principles established in our treatment of infinity.

II. TWO DEFINITIONS OF THE CONTINUUM

a. The *Material Definition*

There are two definitions of the continuum. Each of them must be stated, explained, and defended. The more common definition defines the continuum in terms of its material cause: **The continuum is that which is divisible into what is always further divisible.**[1]

b. The *Formal Definition*

The second definition states that **the continuum is that whose terms are one.**[2] This definition proceeds through the formal cause because every term is a form and vice versa. Throughout this chapter, the first definition will be called the material definition and the second definition will be termed the formal definition.[3]

III. THE CONTINUUM IS ALWAYS DIVISIBLE

a. *Continuum Not Made of Indivisibles: Thesis*

In order to explain and justify the material definition, it will be necessary to show that a continuum is not made up of indivisibles, **i.e., a** solid is not composed of planes nor a plane of lines nor a line of points. In other words, a continuum is not made up of ultimate parts which are incapable of being further divided. Our first and material definition of the continuum will not hold, if a continuum were not divisible into what is always further divisible. The only alternative would be to conclude that divisibility must eventually be exhausted, leaving remainders that are no longer capable of division and are hence indivisible. But as will be seen, no such remainders are possible. **If it can be shown that a continuum is not composed of indivisibles, the only conclusion is that division of the continuum will never resolve into indivisibles, and hence tliat indivisible remainders will never be obtained through division.**

b. *Points Do Not Form a Line: Proof*

In order to make our inductions more forceful, let us consider only that simplest kind *oí* continuum, a line. If a line were divided until **divisibility would be exhausted and indivisibility were reached, a line**

would be made of indivisibilities, and we could expect to put our indivisibles together to get back the original line we divided. But we could never do so. For the indivisibles resulting from our division would have to be points and points cannot be added together to form our original line or any other line. The point B, for instance, that we would add to A would yield no more extension than the original point. It cannot touch the original point with one part of itself and leave another part spread out to touch some other point and thus produce a line. For points, being indivisible, have no parts. Any point that would touch another would totally coincide with that other without ever stretching out beyond it. No matter how many points were "strung together" in this way, they would pile up on top of one another without ever extending, even to an infinitesimal degree, beyond the original point.[4] Therefore, because indivisibles can never be put back together again to yield the origina] line, a line cannot be divided until it yields indivisibles, and hence the line is divisible into what is always further divisible.

c. *Continuum Made of Smaller Continua*

As a line is not composed of points but of smaller lines, so every continuum is composed of smaller continua. A plane is composed of planes, not of lines, and a solid is composed of solids, not of planes.[5] A plane cannot be divided until the parts finally become so small that they are merely lines, and a solid cannot be sliced so thin that the remainders of its division are planes.

According to our analysis in Chapter XIV, any continuum is divisible into a potential infinity of parts;[6] but because of the finite character of the whole, the multitude of the parts can never be actually infinite.[7]

IV. A CONTINUUM IS THAT WHOSE TERMS ARE ONE

a. A *Line Contains Actual Parts*

The second and formal definition of the continuum is more difficult to expound, partly because comparatively little attention has been paid to it. This formal definition defines the continuum as that whose terms are one. It might be approached by showing that since the multitude of parts in a continuum, e.g., a line, is not actually infinite, it must be actually finite. This is to say, using a line once more as an example, that although the quantity of parts on a line is not actually infinite, there are truly actual parts on such a continuum. There are at least two

halves on a line, and even smaller parts as our knowledge of fractions would show. The only way in which the lengthening of a line can be explained is that actual and not merely potential parts are added to the original line; the longer line contains more actual parts than the shorter one because it is actually and not merely potentially longer. In brief, there is ample evidence that any continuum does have actual parts, no matter what it may contain in potency.8

The precise number of actual parts in a continuum, if such a question makes any sense, need not bother us, at least at present. Later on, it will be seen that such a question is meaningless. The point here is only that actual parts are present in any continuum, a line, a plane, or a solid. The geometer, in finding the two halves of a given line, does not bring the halves into existence.9 He simply finds out what and where they are. Tire parts are there, actually, before he studies them.

b. *The Actual Parts Are Distinct Through Indivisibles*

By the very nature of quantity, the parts, e.g., the parts of a line, must be distinct in themselves and distinct from other parts.10 There can be no overlapping of the parts, no running together or compénétration.11 If the parts actually present on a line overlapped each other, they would lose their identity. For in the very nature of quantity, the position of any part is of the essence of that part.12 Two equal straight lines are different only in position. Likewise each part of a line or any other continuum, to be distinct, must have an individual position, shared by no other part. Looked at from another angle, parts that overlapped one another would, when put together, fail to equal the whole. Hence, there are actual parts on, for instance, a line in such a way that each part is distinct in itself and distinct from neighboring parts.

Because of the presence on a line of actual parts that do not compenétrate each other but remain distinct in themselves, it is necessary to hold that there are indivisibles actually present within a continuum.13 These indivisibles, e.g., the points within a line, are not parts of a continuum; for in accordance with our previous conclusion, there are no such indivisible parts. They are terms of parts; they are related to the parts of the continuum as form to matter. The indivisibles here in question have a twofold function. They terminate each part in itself, and they continue each part with the neighboring part. They are indivisible divisors between the parts so that any two parts at the interior of a line have a common term.

It is easy to misunderstand the conclusion we are trying to attain. The indivisible divisors, e.g., the points in a line, the lines in a plane, and the planes in a solid, are not parts of the line, plane, and solid; if they were parts, any continuum would be composed of indivisibles. The indivisibles of any continuum are related to the parts as terms; for example, the points on a line terminate (and continue) the parts, and similarly lines terminate the parts of a plane and planes terminate the parts of solids. That is why the formal definition of the continuum reads "that whose terms are one."[14] Two neighboring parts at the interior of any continuum have a single common term. Terms of neighboring parts are not merely together, not merely adjacent or contiguous if such language makes any sense. They are the same. The terms of a glass and the water inside of it are contiguous but not the same. For the parts of a continuum the terms are identical.

c. *The Size of Actual Parts*

In explaining that every continuum contains actual parts kept distinct from each other by indivisibles, hardly anyone can get very far without encountering a question as to the size of the actual parts: How many actual parts are there? How big is the minimal actual part?

Such questions are almost inevitable, and in order to approach them properly, it is first necessary to identify the kind of part here being discussed. The question here concerns so-called proportional or undesignated parts that make up the being of any continuum, e.g., the being of a line. We are dealing with parts that constitute a line in its **entity.**[15] The concern here is not with the designated parts used in order to **measure** a line. Such parts are capable of being determined by us in their number and in their size. In a twelve-inch line measured by a foot ruler, there are obviously twelve designated parts.

The parts of interest in this chapter are so-called proportional or undesignated parts, the parts which make up the line in its entity by contrast to the parts we use as units of measurement. How many such actual proportional parts are there on a line? Tire answer, if there ever could be an answer, pivots upon the size of the smallest actual part of a line.

But such a minimal part has no actual but only virtual size.[16] **We** cannot apply to the minimal or unit part of a line the same kind of question we ask concerning the line as a whole, i.e., How big or how long is it? The minimal part on a line is like the unit in the number system; the unit is not so much a number as a principle of number.

We can ask: How many units are there in the number 7? but not: How many units are there in one unit? Just as one is not, properly speaking, a number but a principle of number, so the minimal part of a line cannot be discussed by the same standard employed regarding the line as a whole. Furthermore, just as a principle contains the effects that issue from it but in a mode differing from the mode of existence these effects shall have as effects,[17] so that principle of a line which is the minimal proportional part of the line in question is not a line in the same way in which the effect is a line.

d. *The Actual Parts Are Potentially Infinite*

Our conclusion, based on the formal definition of the continuum, that there are actual parts on a line finite in their "number" does not contradict the previous conclusion, based on the material definition, that **the multitude of parts of a continuum is infinite in potency.**[18] **The** actual parts are in potency to a twofold division, and if division occurs not at the term of actual parts but within them, then a new scale for determining sizes must be employed. We cannot compare the size of any actual part to the same standard we use for the continuum as whole. In discussing the formal definition of the continuum, we have been concerned with parts in act, whereas the material definition of the continuum bears upon parts in potency. Hence, there is no conflict between the insistence that the parts in a continuum are actually finite and a previous decision that they are potentially infinite.

V. THE CONTINUITY OF MOTION

a. *The Parts of Motion Follow the Parts of Magnitude*

The continuum in the order of magnitude or quantity yields insight into the continuum at the level of motion and of time. **Motion is continuous because the magnitude that it traverses is continuous.**[19] **Divisi**bility and indivisibility characterize motion in the same manner as they characterize the magnitude through which the motion passes; and from the continuity of motion there is evidence of the continuity of time. The continuity of magnitude is thus the fundamental type of continuity. Motion is continuous because magnitude is continuous, and time is continuous because motion is continuous.[20]

Wherever there is motion, taking the word in its strict sense, there are parts of motion: that is to say, a body in motion reaches its term successively and part by part.[21] It does not go from relinquished to attained term in an instant. The successive parts of motion, e.g., in local motion, correspond to the parts of the magnitude through which the motion passes. For motion is a successive continuum, while magnitude as such is a simultaneous continuum whose parts are all actual at once and not one after another.[22] Local motion, for instance, passes through these parts.

The successive character of motion, e.g., local motion, is evident from experience. A body undergoing local motion does not reach its term in an instant but by degrees. There is a time when such a body is at rest in its relinquished term and a later time when it is at rest in the attained term. In between, there is also a time when it is being moved. To be in a motion and to have completed a motion are not the same thing. To be enroute to Washington and to have arrived in Washington are different "states." Moreover, there is a mid-point enroute and a quarter point, etc. Motion involves parts that can be measured by the parts of the magnitude through which motion takes place. This is true in all motion but can be seen best in local movement.

b. *There Is No Indivisible Moment*

Nothing can be moved in an indivisible "magnitude."[23] The indivisible is a term, and a mobile being in such a term is at rest, not in motion. If a body moves through a magnitude, such a magnitude must be divisible; it must be a whole composed of parts. The term of a motion, where motion is no longer taking place but has been finished, is indivisible;[24] and it is indivisible precisely because it terminates the motion.

Just as a line is not composed of indivisible points but of lines, so motion is not composed of indivisible moments but of motions. If motion were capable of division into indivisible moments, the possession of the attained term would take place without motion. A thing could then go from here to there in an instant. The state of having been moved could then exist without the previous state of being moved.[25] In other words, if motion were a series of indivisible moments, a moving being would be at rest in every one of the stages of motion. To reduce motion to a series of non-motions would really be a denial of motion.

VI. THE CONTINUITY OF TIME

a. *Time Is Not Composed of Instants*

As magnitude is not composed of indivisible quantities and as motion is not made of indivisible moments, so time is not composed of indivisible instants. In local motion, for instance, the traversing of the total magnitude requires a total time and the covering of part of the magnitude requires part of the time. Just as there is no smallest part of magnitude, so there is no smallest part of time, and since there can be no indivisible components of magnitude, neither can there be an indivisible ingredient of time. Time is not composed of indivisible nows but of smaller times. In short, if time is a measure applied to the prior and the posterior in motion, it can be argued that because magnitude is divisible, so is motion and so, finally, is time itself.[26]

b. *The Now Is Indivisible: A Term and Principle*

The now according to our previous analysis is indivisible, and the same now is the term of past and also of the future. If the now were divisible, spreading out as it were like a line in space, the past and the future joined by the now would compenétrate each other; something of the past would be in the future and something of the future in the past, because the past and the future would be mixed by the single and yet divisible now terminating them. The now therefore cannot be divisible, stretching out so to speak across a span of time. If, on the other hand, it be denied that it is the same now terminating the past and opening the future, the two nows would have to be different. Time would then lose its character as a continuous flow. If would be an aggregate of nows. But it could not be an aggregate of indivisible nows any more than a line can be made of indivisible points.[27]

c. *There Is No Rest in the Now*

In an indivisible now, a thing is neither in motion nor at rest. Such contraries when applied to the now have no meaning. It has already been seen that since the now is indivisible there can be no motion in it, and since rest is the contrary of motion there can be no rest in the now if there is no motion in the now. Rest is possible only where there is motion, just as evil is possible only where there is good. Our conclusion

can be reached in another way by insisting that a thing at rest is a thing which remains the same throughout a period of time, i.e., before a certain now and after it.[23] As a line requires at least two points, so rest requires at least two **nows** with time in between them. Whatever is moved or at rest is moved or at rest in time.

VII. THERE IS NO PRIMARY MOMENT OR PRIMARY WHEN

a. *Recapitulation: Motion Is Always Gradual*

By way of making a transition to the next topic in the division of motion, it should be recalled that motion takes place between two contrary and hence two positive terms; when a thing is in its attained term, it is no longer being moved but it has been moved. When a thing is in its relinquished term, the motion has not yet begun. Motion, as such, does not transpire suddenly between the terms but in a gradual and continuous manner, as experience reveals. Indeed, a locally moving body does not move as a whole out of its relinquished term but part by part. If, for instance, a body is moved from A to D along a straight line ABCD, in the beginning of the motion one part of the body in some way corresponds, let us say, to part AB of the line, and at a later time, a posterior part of the moving body corresponds to AB, a prior part of the line, while a fore part of the body in motion in some manner corresponds to BC and an even more prior part of the body corresponds to CD. Since motion in our example is actually going on, it is not proper to speak of a body or even part of a body as being in a certain place; but from our example, it can be strongly argued that a locally moving body according to part of itself is associated more with one part of a trajectory and according to another part of itself with another part of the pathway. **As transpiring between the attained and relinquished terms, a moving body shares in some measure in both of them according to different parts of itself. Motion in the strict sense is essentially an affair of parts.**[29]

b. Is *There a First in Any Motion or Any Time?*

It is possible now to raise some further questions concerning the various stages of motion. Is there a first part or first moment in any motion? It is apparent that when a thing has left its relinquished term behind, **it** has been changed, and our question asks whether there is a first moment

of such change, a primary state in which it would be true to say that there is a certain completion of the change and before which it would be false to make this statement. Our question in a more technical language could also be put: Is there a primary **when** in motion? The term **primary** here is understood as in our previous discussions.[30] It is not synonymous with essential. A thing is changed in an essential way when something of its nature has changed. A thing is changed in a primary way when it is changed as a whole and not by reason of its parts. A primary **when would be the first unit of time in which a whole nature changed, and hence any change that takes place in stages, with one part of the change taking place in part of the time and another part in another, would not have a primary when.**

c. *There Is No First in Motion or Time*

With regard to motion in the strict sense of the term, there is no primary when, or primary moment. There is no first moment or stage in which it would be true to say that a thing has changed and before which this statement would be false. There is no part of a trajectory for which we cannot find an earlier part and no part of time that we cannot find to have been preceded by an earlier time. No matter how early we examine a motion, it will be found that the mobile being, whatever it is, has already been changed earlier in some primary and essential way. There is no first completion of motion properly speaking, no first state of having been changed. In short, motion has no primary moment and no primary when.[31]

VIII. MOTION AND THE COMPLETION OF MOTION

a. *Motion Is Preceded by a Completion of Motion*

In comparing motion to a completion of motion, the following two propositions can be defended:[32]

a) In any motion, no matter when we consider the motion, a prior state of having already been changed can be identified. Whenever it is true to say of a body that it is moving, it is also true to say of the body that it has earlier completed a movement or was earlier in a state of having been moved.

b) In any state of having been changed or of having completed a

movement, no matter when we consider the motion, a prior state of motion can be identified. Whenever it is true to say of a body that it has completed a movement or is in the state of having been changed, it is also true to say of the same body that it has earlier been undergoing motion.

In order to prove the first point, assume that in a time represented by a line AB a body goes through a trajectory represented by a line XY. In half the time, as marked off on AB, the body, if being moved uniformly, will have covered half of the trajectory as marked off on XY. The principles of the continuum are involved in our problem, so that no matter how early in its trajectory we examine a movement we can always find that a certain portion of the motion has already occurred, because a certain part of the trajectory has been covered; in any motion that is in progress a prior state of having been moved can be identified.

In our present context, any completion of a motion or any state of having already been moved is comparable to a point on a line. As a point terminates a line or part of it, so a state of having been changed is a term or completion of a motion. No matter how small a line or part of a line we may be considering, it remains true that there is a point prior to the terminal point, as X would be prior to Y in our language of the preceding paragraph. In a similar way, no matter how small a progress a motion may have made toward its goal, there is a state of having been changed which can be found to have preceded it. But motion is not a mere series of completions of motion or of states of having been changed. As St. Thomas writes in this regard, "But just as a point in a line is potentially there prior to the division of the line but in act when the line is actually divided, since the point is the very division of the line, in a similar way what we call the state of having been changed in motion is in potency when the motion is not terminated there, but will be in act if the motion is there terminated."[33]

Hence, the state of having been changed which already exists whenever a motion is underway has the same kind of potential existence as a point prior to the actual division of a line. In fact, the conclusion we are trying to draw can be supported by comparing any line with a shorter line and any motion with a shorter motion already terminated. Just as we know that our longer line can be divided into a smaller line because it can be compared with our shorter line, so it can be argued that the state of having already been changed exists in any motion because we can compare this motion with a shorter motion already terminated where the State of having been changed is more apparent,

b. A *Completion of Motion Is Preceded by Motion*

Our second proposition concerning motion and its completions affirms that in any state of having been changed or in any completion of a movement along its trajectory, a prior state of motion can be identified. If, according to our previous example, the state of having been changed is like a point and motion is like a segment on a line, then, just as prior to any point after the beginning of a line there is a line segment, so prior to any state of having been changed there is motion. Our argument can be put in grammatically simpler terms by simply saying that if the state of having been moved is a term of the state of being moved, then the latter precedes the former.

At the conclusion of this analysis, it may be said that everything that has been moved was previously being moved and everything that is being moved has previously attained some kind of act that we have called the state of having been moved or changed. Both of these propositions are true. Both of them can be true at the same time because motion is a mixed reality, an imperfect act; a thing in motion is constantly other than it was.

IX. THE FINITE AND INFINITE IN MAGNITUDE, MOTION, AND TIME

The finite and the infinite are found in a similar way in magnitude, in motion, and in time.[34] In each case there is a number of parts actually finite but always divisible into smaller parts and hence potentially infinite. Motion and time are like the lines of magnitude; the state of having been moved in the case of motion and the now in the case of time are like the points. As on a continuous line there is no part that is absolutely first or last but always terminated parts that may be more and more finely divided, so there is no smallest part of motion nor smallest part of time.

Just as there is no first part of motion, so there is no first part of rest or first when in which a thing is at rest.[35] But as the principles for proving these truths are the same as those employed above, the reader is left to determine them for himself.

X. THE RELEVANCE OF STUDYING THE CONTINUUM

a. Zeno's Paradoxes

The nature of the continuum, as discussed in this chapter, is not a mere dialectical exercise. The problem, and some would even say mystery, of the continuum is one of the oldest problems that have plagued Western thinkers from the Greeks on down to the present time. In the ancient world, the name associated with the continuum is that of Zeno, whose study of quantity persuaded him that motion is really impossible and is hence only an illusion of our senses. Several arguments were proposed by Zeno, of which only one will be considered here.

Consider an archer shooting an arrow at a target. In order to reach the target, Zeno said, the arrow would have to go through an infinity of intervening points, for the multitude of points between the archer and the target is truly infinite. Even if the arrow were to go halfway to the target, it would have to traverse a line containing an infinity of points, and since the infinite cannot be traversed, our arrow could not even reach this halfway point. A fourth of the distance to the target also contains an infinity of points, and so does an eighth, a sixteenth, etc. **Even the smallest distance toward the target, being a line, contains an infinity of points according to Zeno's logic. Hence, because the infinite cannot be traversed, even the smallest amount of motion toward the target becomes impossible.**[36]

The mistake of Zeno's argument is to attribute an actually infinite character to the components of a continuum. Thus, he argued that **any** line, however small, between the bow and the target contains an infinity of pointlike units of composition. According to our analysis, the number of parts (and hence the number of their terminal points) on any line is infinite only in potency; actually it is finite. Hence the distance, as actually finite, can be traversed, and traversed indeed in a finite time. Zeno's mistake, therefore, was to attribute to a continuum an actually infinite character whereas it is infinite only in potency. Zeno saw only the multiplicity of the continuum and ignored its unity.[37]

It is not necessary here to explain the rest of Zeno's arguments. All of them involve the same error as the previous one, the confusion of the potentially and the actually infinite, and hence all of them can be answered by using the same principle: i.e., the number of parts in a continuum, while potentially infinite, is actually finite.

b. *Quantum Theory*

Another problem concerning the continuity of matter and of motion is of a quite different kind and takes its most emphatic form in that system of modern physics called quantum theory. This theory may be illustrated for present purposes by the Bohr theory of the hydrogen atom. The single electron which revolves about the hydrogen nucleus like a planet orbiting around the sun can be excited until it reaches orbits more and more distant from the nucleus of the atom. As the electron falls back from less stable outer orbits to a more stable orbit closer in toward the nucleus, there is an emission of light in the form of a packet of energy called a quantum. This theory became a basis for explaining how various substances can be excited to emit radiation.

But how does the quantum theory, as illustrated by the Bohr atom, raise the problem of continuity?

It does so because the electron falling from an outer orbit to an inner one is thought to leap or jump across the intervening space. If you draw a series of concentric circles about some point representing the nucleus of a hydrogen atom, an electron revolving in some outer circle can in an indivisible manner leap into an inner one without going through the space separating the circles. It is in one orbit and then by some indivisible action appears instantaneously in another one. **According to this view and according to later developments of quantum mechanics, nature in its submicroscopic dimensions operates in an indivisible and discontinuous fashion.**[38] This would seem to contradict our previous conclusion that motion is gradual and successive and that magnitude, no matter how small, is always continuous and divisible.

In reply to this objection, it should be stressed that the approach to the continuum in this chapter which denies that motion is indivisible rests upon principles more general and more certain than our specialized notions concerning the details of nature.[39] The quantum theory, especially in its physical implications, is at most only a hypothesis, capable of being modified by the future of research; we have only an indirect and hazy knowledge of events in the submicroscopic regions of the real, and it may be that a theory not yet projected will some day be able to give a better physical account of the microworld than quantum mechanics does today. In fact, in its physical meaning the theory of relativity with its space-time continuum even now contradicts the quantum notion that matter is discontinuous.[40]

Such a verdict is not meant to belittle quantum theory. It is the best

general theory we have for dealing with the microphysical world and should at all costs be retained until a better explanation comes along. But it is a dialectical instrument. Inductions made by its means are highly conditioned by the dialectic itself and are not pure and unqualified truths. When there is a conflict between some well-established principle based on general experience and hypothetical conclusions that are more or less dialectical, the more certain knowledge should always be accepted in preference to the less certain; and when the more or less dialectical notions do not seem compatible with the more certain knowledge, judgment should always be reserved on the dialectical inductions as being tentative. Above all, a dialectical construction should never be allowed to obscure the well-established truths based on general experience.

c. *The Mathematical and Physical Again*

The quantum theory provides a lesson appropriate to a fundamental theme of this book. Prior to this theory, the atom was conceived in terms of a mathematical model, using geometry of a billiard ball and even the planetary system. When this geometrical model broke down, it was argued that nature is indetermined and discontinuous. As no longer reducible to exact mathematical law, nature was conceived to move by leaps and bounds.

But whether or not the microworld is continuous is not a question for mathematics. There is more to nature than mathematics can describe and more to matter than the geometry of space. In short, there are strictly physical questions concerning nature that only a strictly physical science can resolve;41 a mathematical physics cannot understand everything that the mind wants to know concerning nature, especially the most basic questions that belong to our general science.

There are two alternatives open here: One is to use as a standard of explanation a mathematical model of the universe and to write off anything that does not fit this model as unintelligible, i.e., as discontinuous and indeterminate. The other option is to abandon the mathematical model as the ***basic*** scheme explaining nature and to admit a strictly physical level which cannot be reduced by mathematical techniques. Using arguments like those in these pages, we could then hold to the continuous and determinate character of matter, but frankly admit that our mathematics cannot translate the strictly physical dimension of our mobile world. If the arguments developed in this chapter are correct, the second alternative is not merely an option but a logical necessity.

XI. SUMMARY AND CONCLUSION

In this chapter, the quantitative parts of motion have been considered. In explaining the material definition of the continuum, it was shown that continuous quantity, e.g., a line, is always divisible into further divisible parts. In explaining the formal definition of the continuum, it was shown that the parts of a line, for example, are finite in number at any one time and that there are indivisible divisors between the parts, e.g., the points on a line. Motion is continuous because magnitude is continuous, and time is continuous because motion is continuous. There is no smallest part of motion and no smallest part of time; for any "part," a smaller part can always be found. There is no first moment or stage of any motion and no first period of time during which the motion occurs. In any motion, no matter when we consider the motion, a prior completion of motion can be identified; and in any completion of motion a prior stage of motion can be found. Our chapter ended with a consideration of Zeno's problem and with a glance at modern quantum physics. Zeno erred by thinking that the parts of a continuum are infinite in act whereas they are infinite only in potency. The view of quantum theory that motion is discontinuous is hypothetical; it is dialectical. It cannot contradict the conclusions based on more general experience that magnitude is continuous, that matter cannot be resolved into indivisible components, that motion cannot be resolved into a series of moments, and that time cannot be resolved into a series of instants.

REVIEW QUESTIONS

1. State the two definitions of the continuum.
2. Prove that no continuum, e.g., a line, is made of indivisibles.
3. How does this establish our material definition of the continuum?
4. Show that a continuum has actual parts.
5. Why is it necessary that there be indivisibles in a continuum?
6. Prove that there is no meaning to the question concerning the "size" of the actual parts.
7. Show that there is no conflict between the presence of actual parts in a continuum and the potential infinity of a continuum.
8. Show that motion is continuous.
9. Explain that there is no indivisible moment in motion.
10. Show that time is continuous.
11. Show that time is not composed of instants.
12. Prove that rest is not instantaneous.
13. Explain that motion has no primary moment nor time a primary when.
14. Prove that motion is preceded by a completion of motion.

15. Show that a completion of motion is preceded by motion.
16. Explain how magnitude, motion, and time are finite and infinite in the same way.
17. Give one example of Zeno's paradoxes and evaluate this example as proving that motion is impossible.
18. What is the problem of continuity as it appears in modern quantum theory?
19. Does the quantum theory prove the discontinuity of matter? Explain.

PROBLEMS

Explain the following passages:

I

"Now if the terms 'continuous,' 'in contact,' and 'in succession' are understood as defined above — things being 'continuous' if their extremities are one, 'in contact' if their extremities are together, and 'in succession' if there is nothing of their own kind intermediate between them — nothing that is continuous can be composed of indivisibles: e.g., a line cannot be composed of points, the line being continuous and the point indivisible. For the extremities of two points can neither be one (since of an indivisible there can be no extremity as distinct from some other part) nor together (since that which has no parts can have no extremity, the extremity and the thing of which it is the extremity being distinct).

Moreover, if that which is continuous is composed of points, these points must be either continuous or in contact with one another: and the same reasoning applies in the case of all indivisibles. Now for the reason given above they cannot be continuous: and one thing can be in contact with another only if whole is in contact with whole or part with part or part with whole. But since indivisibles have no parts, they must be in contact with one another as whole with whole. And if they are in contact with one another as whole with whole, they will not be continuous: for that which is continuous has distinct parts: and these parts into which it is divisible are different in this way, i.e., spatially separate.

"Nor, again, can a point be in succession to a point or a moment to a moment in such a way that length can be composed of points or time of moments: for things are in succession if there is nothing of their own kind intermediate between them, whereas that which is intermediate between points is always a line and that which is intermediate between moments is always a period of time.

"Again, if length and time could thus be composed of indivisibles, they could be divided into indivisibles, since each is divisible into the parts of which it is composed. But, as we saw, no continuous thing is divisible into things without parts. Nor can there be anything of any other kind intermediate between the parts or between the moments: for if there could be

any such thing it is clear that it must be either indivisible or divisible, and if it is divisible, it must be divisible either into indivisibles or into divisibles that are infinitely divisible, in which case it is continuous.

"Moreover, it is plain that everything continuous is divisible into divisibles that are infinitely divisible: for if it were divisible into indivisibles, we should have an indivisible in contact with an indivisible, since the extremities of things that are continuous with one another are one and are in contact."

Aristotle, *Physics* 2

II

"So that which has changed must have been changing and that which is changing must have changed, and a process of change is preceded by a completion of change and a completion by a process: and we can never take any stage and say that it is absolutely the first. The reason of this is that no two things without parts can be contiguous, and therefore in change the process of division is infinite, just as lines may be infinitely divided so that one part is continually increasing and the other continually decreasing.

"So it is evident also that that which has become must previously have been in process of becoming, and that which is in process of becoming must previously have become, everything (that is) that is divisible and continuous: though it is not always the actual thing that is in process of becoming of which this is true: sometimes it is something else, that is to say, some part of the thing in question, e.g., the foundation-stone of a house. So, too, in the case of that which is perishing and that which has perished: for that which becomes and that which perishes must contain an element of infiniteness as an immediate consequence of the fact that they are continuous things: and so a thing cannot be in process of becoming without having become or have become without having been in process of becoming. So, too, in the case of perishing and having perished: perishing must be preceded by having perished, and having perished must be preceded by perishing. It is evident, then, that that which has become must previously have been in process of becoming, and that which is in process of becoming must previously have become: for all magnitudes and all periods of time are infinitely divisible.

"Consequently no absolutely first stage of change can be represented by any particular part of space or time which the changing thing may occupy."

Aristotle, *Physics* 3

NOTES TO CHAPTER XVIII

1. Phys., Bk. VI, ch. 1, 231b, 15-16. There are also many references to this definition in the works of St. Thomas; cf. e.g., *Com. on the Phys.,* Bk. I, **les. 3, n. 59; Sum. cont. Gent., Bk. III,** ch. 12; Com. on On the Heavens, Bk. I, les. 2.
2. *Phys.,* Bk. VI, ch. 1, 231b, 17; cf. also, for instance, Com. on the Phys., **Bk. IV, les. 21, n. 1180; Bk. VI, les.**

1, n. 1450; *Com. on On the Heavens,* Bk. I, les. 2.
3. For differences between material and formal definition, cf. Com. on *the Phys.,* Bk. II, les. 15, n. 535.
4. Cf. Chapter XIV; for a primary source, cf. Com. on the *Phys.,* Bk. VI, les. 1, n. 1453.
5. Com. on On *the Heavens,* Bk. Ill, les. 3, 4.
6. Cf. supra, p. 278 ff.
7. Summa Theol., I, q. 7, a. 4.
8. Sum. cont. Gent., Bk. II, ch. 49; Com. on *the Sense,* 15; Com. on On *Generation,* Bk. I, les. 4, 5; Exposition of *the Post. Anal.,* Bk. II, les. 10; On Truth, q. 22, a. 14.
9. "Punctum enim nihil est aliud quam quaedam divisio partium *lineae." Com. on On the Heavens,* Bk. Ill, les. 3.
10. Com. *on the Trim,* q. 2, a. 2, reply 3.
11. John of St. Thomas, Curs. *Phil., Phil. Nat.,* I. P. Q. XX, a. 1, ed. Reiser (Turin, 1930), II, 417-418.
12. Com. *on the Trim,* q. 4, a. 2, reply 3.
13. Exposition of the *Post. Anal.,* Bk. II, les. 10.
14. Cf. supra, p. 348.
15. John of St. Thomas, Curs. *Phil., Phil. Nat.,* I, P. *Q.* XX, a. 1, II, 416.
16. Ibid., a. 2, II, 424.
17. For the relation between unity and number, cf On Truth, q. 2, a. 1.
18. Cf. supra, p. 348.
19. *Phys.,* Bk. VI, 231b, 18 ff.; Com. on the Phys, Bk. VI, les. 2, n. 1459.
20. Summa Theol, I, q. 52, a. 1; Com. on the Phys, Bk. VI, les. 3, n. 1474 ff.
21. Exposition of the Post. Anal, Bk. II, les. 10.
22. Summa Theol, I, q. 7, a. 4, reply 1.
23. Phys, Bk. VI, ch. 1, 232a, 7-9; Com. on *the Phys,* Bk. VII, les. 6, n. 1862.
24. Com. on the *Phys.,* Bk. VI, les. 7, n. 1589.
25. Summa Theol, I, q. 53, a. 1, reply 1.
26. On the *Power* of God, q. 3, a. 17, reply 24; Com. on the *Phys,* Bk. VI, les. 4 (passim); Com. on *the Met.,* Bk. II, les. 10, n. 2354.
27. *Phys.,* Bk. VI, ch. 3, 234a, 5-8; Com. on *the Phys.,* Bk. VI, les. 5, n. 1523.
28. Com. on the Phys, Bk. VI, les. 10, nn. 1681-1683.
29. Summa Theol, I, q. 53, a. 1, reply 1.
30. Cf. Chapter XVII, supra, p. 328.
31. Com. on the Phys, Bk. VI, les. 7 (passim).
32. Phys, Bk. VI, ch. 6 (passim); Com. on the Phys, Bk. VI, les. 8 (passim).
33. Com. on *the Phys,* Bk. VI, les. 8, n. 1623. Cf, also, Exposition of the *Post. Anal.,* Bk. II, les. 10.
34. *Phys.,* Bk. VI, ch. 7 (passim); Com. on the *Phys,* Bk. VI, les. 9 (passim).
35. Phys, Bk. VI, ch. 8, 239a, 10-11; Com. on the *Phys.,* Bk. VI, les. 10, n. 1681 ff.
36. Phys, Bk. VI, ch. 2, 233a, 21 ff.
37. Com. on the *Phys.,* Bk. VI, les. 11, n. 1701.
38. Cf, for instance, E. Schroedinger, Science and *Humanism* (Cambridge, 1951), p. 39 ff.
39. Cf. Chapter II, supra, pp. 36 ff.
40. Cf. also Albert Einstein, On the *Method of Theoretical Physics* (New York, 1933), p. 19.
41. B. Ashley, "Research into the Intrinsic Final Causes of Physical Things," Proceedings of the American *Catholic Philosophical Association,* XXVI (1952), 189.
42. Bk. VI, ch. 1, 231a, 21-231b, 17.
43. Bk. VI, ch. 6, 237b, 2-23.

CHAPTER XIX

FIRST AND UNMOVED MOVER

I. INTRODUCTION

a. *Why Our Science Inquires About a Prime Mover*

The general science of nature is concerned with the universal causes or principles in the mobile world. If there were no separate treatment of material being in general and hence no distinct discussion of the general causes and principles of motion, it would be necessary to begin every study of a particular type Of mobile being by first asking general questions, because these general questions are ones that logically occur prior to more specialized investigation. If the study of each particular kind of material thing would begin with the same questions concerning the causes of motion in general, there would be a useless repetition concerning the universal principles of motion, the definition of nature, the four causes, the character of motion in general, infinity, place, time, and the divisions of motion. In order to avoid useless repetition every time we examine a new kind of material being, there should be a separate treatment at the beginning of natural science concerning the universal principles and causes of mobile being. It is this treatment that we have called the general science of nature.[1]

There is one capital question within this general science which has not yet been asked and which, because of its extreme difficulty, is reserved to the end. It is the question of the universal efficient cause of mobile being, the question of the Prime Mover. What is the relation of motion to its movers? Is there a First and Unmoved Mover of the **material world?**

b. Two Ways *of Knowing God*

There are two ways of coming to a knowledge of God in this life. One is a supernatural way in which God reveals Himself to man; this knowledge, obtained by the infusion of faith into our souls, is elaborated in that science which is called sacred theology or Christian doctrine. Another way of knowing that there is a God is by reasoning to His existence as the Supreme Cause of the creatures that are around us.[2] Proof for the existence of God, known to us by reason as the Supreme Cause of creatures, is begun in the general science of nature, and developed and perfected in metaphysics or natural theology. The consideration of a Prime Mover is, in our science, not an exercise in apologetics, but a necessity in our quest for causes and principles to explain motion and the mobile. Just as we inquired about the universal material cause of mobile being and found it to be primary matter, so it is proper to our general science of nature to seek the universal efficient cause of material things. Even if we could succeed only in showing that a cause of this kind exists, this proof would be a tremendous achievement on the part of human reason.

c. *The Climax of Our General Science*

Everything that has been studied so far after the formal opening of our general science can be seen as a preparation to prove the existence of a Prime Mover and to discover whatever our general science can establish concerning the "nature" of that Prime Mover. If we list the subjects we have treated after our preliminary chapters (Chapters I–XIII) it can be seen that our definition of motion, along with our demonstration of what the subject of motion is (Chapter XIV), enables us to give one of the most useful formulations of the principle of efficient causality: Whatever is moved is moved by something other than itself. The second subject that followed our prefatory material, infinity (Chapter XIV also), enables us to penetrate the second major part of our argument for a Prime Mover: Among movers essentially subordinated to each other there is no infinite series. From Chapter XV down through Chapter XVIII, every major topic contributes to an understanding of the principles both in the proof for a Prime Mover's existence and in proofs concerning attributes of that Prime Mover. The discussion of the First and Unmoved Mover is truly a climax of our general science.

II. SUMMARY OF OUR PROOF

a. *Motion Requires a Mover*

The most effective way of reaching the objective of our present chapter is first merely to explain the proof for a Prime Mover and afterward to establish the proof. Once the reality of a Prime Mover is shown, it will then be logical to ask about the attributes of such an Unmoved Mover insofar as they can be gleaned from material so far studied in our general science.

Our first key proposition reads: **Whatever is moved is moved by something other than itself.**[3] **If a nail is driven into wood, it must be driven by a hammer; and if, in turn, the hammer is moved to drive the nail, the hammer must be moved by something else, say the hand; and if the hand is moved, we have yet another cause, etc.** Hence, our proposition says that even a mover, if moved to act, must be moved by something other than itself. Nothing is self-moved. If **C** is moved there must be an extrinsic cause for the motion, say B; and if B is moved in order to cause **C's** motion, it is moved by something other than **B,** i.e., there must be another extrinsic cause, **A.** And so on. In this way there may be a series of causes, one moving another toward the production of that effect which we have to explain. Our principle of causality states that whatever is moved is moved by something other than itself. There must be an extrinsic mover whenever there is motion. There is never any self-motion in the strictest sense of the word.

Motion is being taken for the present in a strict sense of a gradual, successive, and divisible process. If we looked to substantial change, it would become even more necessary to insist that whatever comes to be requires an extrinsic mover; for generation goes from non-being to being and if what is generated were self-generated, if it could bring itself into existence, it would have to exist before it existed, i.e., to exist as a cause and then to bring itself into existence, as an effect. This is clearly a contradiction.

But despite the evident need for an extrinsic cause in order to bring about generation, our proof for a Prime Mover is going to rest on the analysis of motion in the strict sense. This is the most manifest kind[4] of change, and even if there were no substantial changes in our world, motion in the strict sense would furnish evidence that there is a Prime Mover.

In claiming that whatever is moved is moved by something other

than itself, our meaning will be that nothing can move itself in a primary way, that is, as a whole. What is primary in anything, according to our *division* of motion, is what essentially belongs to a thing when we take it as a whole as opposed to taking it according to its parts.[5] We admit that it is possible for a thing to move itself according to its parts. This is evident in the so-called self-motion attributed to living things; thus, the nervous system moves the muscles in the locomotion of a dog and the muscles move the limbs of the animal. In this light every living thing is characterized by a certain kind of self-motion, but it is self-motion where one part of the thing in question moves another part. It is self-motion but not in a primary way. If the reality that was being moved were precisely the same reality that is doing the moving, then the motion would be self-motion in a primary way, and our argument shall show that this kind of self-motion is impossible. There is nothing to prevent self-motion where one part of a whole moves another part.[6] Whatever is in motion, however, cannot be precisely the cause producing the motion. Whatever is being moved cannot be exactly the same thing as the mover of the motion in question. A whole cannot move itself as a whole. This must be established after we explain the rest of the argument for a Prime Mover.

b. *The Series of Movers Is Not Infinite*

Our second proposition in proving that a Prime Mover exists states that in a series of movers where one moves another there is no actually infinite series, and so there must be a First Mover.[7] By way of elaborating on this proposition prior to proving it, it should be borne in mind that the series here in question is a series of essentially subordinated movers. Our distinctions between the essential and the accidental in Chapter XVII can be of service at this point. In a series of movers that are only accidentally subordinated to one another, an actual infinity is possible.[8] A chicken comes from an egg, an egg from another chicken, and the other chicken from still another egg; there is no reason why such a series, stretching backward through the past, cannot be unending. In a series of this kind, the movers, operating not together but in succession, are accidentally subordinated to one another in the sense that a parent chicken need not be here and now influencing the hatching of an egg and may in fact even be dead. In movers essentially subordinated to each other, one mover is here and now influencing another, like the hand swinging a hammer, so that without the causality of the first there is

no movement in the second.[9] In the driving of a nail, there is only an accidental subordination of the hammer's motion to the maker of the instrument, and in fact the maker may no longer be in existence when his tool is operating. But there is an essential subordination of the hammer to the hand that is here and now swinging it.

In summary, our concern at present is not whether in a series of movers accidentally related to each other there is an actual infinity but whether in a series of essentially subordinated movers there is an actually infinite chain of causes. **If there is no actual infinity in the series of causes here and now operating in such movements as the driving of a nail, the blowing of a leaf, or the evaporation of water, then the series of movers, being actually finite, must come to an end. This** means that there must be a Prime Mover.

With the explanations of terms in our argument for a Prime Mover, the two crucial propositions of our proof remain to be established: whatever is moved is moved by something other than itself; and, in a series of essentially subordinated movers, there is no actual infinity.

III. WHATEVER IS MOVED IS MOVED BY SOMETHING OTHER THAN ITSELF

a. Summary of Our Notions of Efficient Causality

From earlier discussions in these pages, important evidence can be adduced for the principle of causality: Whatever is moved is moved by something other than itself.

1. In replying to David Hume's analysis which turned efficient causality into a mere affair of temporal sequence, **it was shown that such a solution to the problem of causality would make the cosmos into a chaos. Whatever** could move itself could break into movement or variations of movement in any imaginable way, and the universe under such a condition would be a sheer spree of chance. Anything could do anything.[10] Self-motion would engender a chance world, but not the universe we experience. In contrast to this, the presence of order in our world indicates that things are not self-moved and hence freakish; this order indicates that things are moved only under the controlling influence of causes. A thing in nature cannot do anything whatsoever but is limited in what it does by the need of a mover outside of it.

2. In a more positive way, the subject, form, and privation involved in all motion are each powerless to explain the fact that motion does

occur. They enable us to understand **what** motion is but not **that** it is in the real world. Privation, to begin with, cannot be an agent because it is non-being, and what is non-being cannot operate to make or move anything. If the subject (matter) and the form cannot explain the motion which brings about the evolution of form from matter, then it is necessary to go outside the intrinsic principles of motion in order to find the mover which explains the motion. The subject of a motion, precisely insofar as it is a subject, is potential. Since the potential, as potential, cannot perform operations, the subject of motion as such cannot be the agent or mover for the motion. Form, the term of motion, is in existence only insofar as the motion is completed. As a principle that is actually present only to the extent that motion is over, the form attained cannot be an initiator of a motion. Since the intrinsic principles of a motion cannot be the mover required for the motion in question, it is necessary that there be a mover extrinsic to the motion, that is, extrinsic to the subject undergoing the motion and the form terminating motion. Whatever is moved is moved by something other than itself.

3. From what has previously been proposed, another lead toward our principle of causality can be found in the relation of motion to action and passion.[11] Motion was seen to be the act of the potential insofar as it is potential, and insofar as motion is related to its subject in which it occurs, it was shown to be passion. But a patient requires an agent because the potential cannot be reduced to act except by something already in act.[12] In other words, as characterizing a patient, motion **requires an agent from which it comes.** There is as much need for an agent when there is motion as there is need for selling when there is buying or for an exterior angle of a figure when there is an interior.

b. *Nothing Moves Itself in a Primary* Way

Our three approaches to efficient causality are intended to be **inductions,** prepared by dialectical preliminaries, that whatever is moved is moved by something other than itself. The discussion of the divisions of motion in Chapters XVII and XVIII permits a **demonstration** of the principle of causality insofar as natural science can study it. At the risk of repetition, it should be observed that in this context this principle is applied only to motion in the proper sense because this kind of change is what is properly and directly known to us and forms the property of our subject, mobile being.[13] Whatever is moved, with motion here being taken in its strict sense, is moved by something other than itself. And

again, in order to clarify what we intend to do, we propose that there is no self-motion in a primary way. Whatever would move itself in a primary way and hence would not depend, for motion, on something other than itself would be an impossibility. Let us turn to the physical proof of this proposition.[14]

Anything that moved itself primarily would not come to rest because some part of itself, i.e., the cause, comes to rest. Putting this in a more positive vein, let us propose that whatever comes to rest because part of itself comes to rest is moved by that very part.[15] For X to come to rest because Y, a part, comes to rest is a sign that Y is a mover of X. If Y comes to rest but X keeps on moving, there is evidence that Y is not a mover of X. If the hand of a walking person comes to rest in the sense of stopping its swinging motion but at the same time the legs continue to move in local motion, it can obviously be argued that the motion of the hands is not causing the walking motion of the man.

All of these judgments can be clarified if we apply them to an example:[16] Let AB be a body in motion, and let us suppose AB to be self-moved in a primary way. As we showed in the previous chapter, whatever is moved is divisible. Hence, since there is no incongruity in actually dividing what is divisible, let the mobile and hence divisible body AB be divided at C into AC and BC. Suppose that because BC comes to rest, the whole AB comes to rest. In this case it can be concluded that the whole AB is moved by reason of a part, this time BC. Because the whole is moved by a part, it is not self-moved in a primary way. If the whole were moving a whole, it would not come to rest upon the rest of a part, and if it be further argued that after division AB is no longer the same whole, it can be proposed that we have controlled it by controlling the part. The whole's motion thus depends on that part.

If BC, a part of AB, is now made to come to rest and the whole AB keeps on moving, then the whole AB is moved while the part BC is at rest, and the motion of the whole is thus caused by the motion of the other part, AC. Since the motion of the whole, AB, is caused by the motion of the part, AC, the whole is not moving the whole, and hence AB is not self-moved in a primary way. If AB were self-moved in a primary way, then when BC would come to rest so would AB. For BC and AB, on our supposition, are one primary whole.

If BC comes to rest and AB either comes to rest, as in our first assumption, or continues to move, as in our second one, no matter which of the alternatives is true, our point is proved: AB is not self-moved in a primary way. If BC comes to rest and AB also does, it can be argued

that whatever comes to rest because part of itself comes to rest is moved by that very part. AB is thus moved by BC on such an assumption. If it is assumed that BC comes to rest and AB continues to move, it can be argued that nothing which is self-moved in a primary way could continue to be moved as a whole when one of its parts came to rest; for on this supposition motion would be caused not by what belongs to a thing as a whole but by what belongs to it by reason of the other part.[17]

That nothing can be self-moved in a primary and essential way is a direct consequence of the divisibility of motion. As St. Thomas Aquinas writes:[18]

> . . . Aristotle shows in Book Six that in motion nothing primary is found on the part either of time or of magnitude or of mobile being, because of the divisibility of these realities. For there cannot be found anything primary whose motion does not depend on something prior since the motion of the whole depends on the motion of the parts and is divided into them, as is proved in Book Six.

It would be easier to show that generation, the change from non-being to being, always requires a mover; but our proof is taking motion in its strict and most obvious sense as a gradual and continuous process. Even here a mover is always required. No continuum can move itself;[19] nothing divisible contains primary self-motion.[20] **Hence, it must be concluded that a divisible whole is moved by something other than itself, namely, the parts of the whole; and so whatever is in motion, in the proper sense of the term motion, is moved by something other than itself.** This was our first crucial proposition to prove the existence of a Prime Mover.

c. *Objection: The Law of Inertia*

An introductory work of this sort is hardly the place to treat technical objections against any of our basic propositions. Nevertheless, there is at least one common difficulty that must be mentioned, as it arises out of science in the modern sense. The difficulty is the law of inertia which is the first and basic law of Newtonian physics.[21] According to this well-known law or axiom, *a* mover is necessary in order to start a body in motion or to increase or decrease the velocity of a moving body; but once in motion, the axiom says, a body will continue to move at the same uniform rate without the need of an external agent. Newtonian physics would seem to authorize the view that motion at a constant velocity does not require an extrinsic mover but that a mover is required only where there is acceleration.[22]

According to the position we have outlined above, a mover is needed not merely to initiate a motion or to change the velocity of a moving body. Indeed, a mover is necessary wherever there is motion and for as long as the motion endures. Assume a body moving along a straight line XY and having arrived at some intermediate "point," C. On this supposition, it would be proper to say that the body had completed the XC part of its trajectory but has yet to accomplish the CY portion of its movement. Now having arrived at C, the body is potential[23] to cover the distance CY—indeed just as potential to go through CY as it was potential, prior to the motion, to go through the whole XY. Since the body at C is only potential to cover the distance CY, it needs a mover to move it through the distance in question; it cannot move itself through CY in a primary way because it can be subjected to the same analysis as our body AB which we considered to be already in motion like an inertially moving body going from C to Y. A body needs a mover not only to start in moving but to keep it moving as long as the motion goes on.

It may not be possible to name the mover of a body moving at a constant velocity and approximating the mathematics of Newton's axioms. There are several theories in the history of philosophy concerning the causes that keep a body, e.g., a projectile, in motion after its initial push or pull.[24] Our proof for an extrinsic agent in all motion is a general one which does not require us to know in any exact way the particular agents in this or that type of motion, but assures us that such an agent must always exist if motion exists. Our proof rests on the nature of motion itself. As divisible, motion does not have a primary character, and so a projectile or a bullet or any other body moving even at a constant velocity from X to Y would require a mover to keep it going. For a mover is necessary to start it from X because there is nothing primary in the motion of the body that could make it move itself from X; having arrived at some intermediate point C, the body even at a constant velocity cannot move itself from C because there is nothing primary that could make it move itself from C. The same logic could be applied through all intervals of distance between X and Y, and our conclusion remains that projectiles, even after leaving their projectors, still require extrinsic agents throughout all moments of their motions.

To find the causes operating on a projectile is a different question from asking whether there are causes to begin with. To find such causes involves knowledge more distinct and particular than the general knowledge: whatever is moved is moved by something other than itself. It is

possible to answer our general question, whether all motion requires a cause, without knowing the answers to more particular questions concerning the precise causes of particular kinds of motion.[25]

IV. THERE IS NO ACTUALLY INFINITE SERIES OF MOVERS

Our second proposition, central to the proof for a Prime Mover is: In a series of movers, essentially subordinated to each other, there is no actual infinity.[26] If, as our proposition reads, the series of movers is finite, there must therefore be a First Mover. It now remains to prove that in essentially subordinated movers there is no actually infinite series.

a. *An Infinite Series Would Occupy Infinite Space and Take an Infinite Time*

Let us lay down again an example of an essentially subordinated series of movers. Take the case of a hand moving a stick that in turn moves a stone along the ground.[27] The hand is a prime mover among the members mentioned, the stick is a moved mover, and the stone is merely moved. In more general terms, **A** moves **B,** and **B** moves **C,** and **C** is moved. It is, of course, possible to have many more members of a series of motions and movers. But our argument says that the series of essentially subordinated movers is finite and that therefore there is a First Mover.

The moved effect and the mover, in any motion, are simultaneous. The hand moves the stick, and as soon as the hand stops moving it, the stick stops being moved. When a builder stops building a house, the house stops being built. A moves B, and as soon as A stops moving, **B** ceases to be moved. If **B** in turn moves **C,** then as soon as **B** stops being moved by **A, C** stops being moved by **B.** In a series of movers, however long, all of the members must be operating in some kind of simultaneity. Moreover, as strictly physical and hence dependent on quantity in the hierarchy of substance plus quantity plus quality plus the motions of matter, our series of natural causes must be stretched out so that one is outside the other—like the stick that is touched by the hand and in turn touches a stone. Physical causes are in continuity or at least in contiguity[28] with each other. In terms of another example, the carpenter touches the hammer that touches a nail that in turn touches the wood. Whatever is quantified, like physical causes, is hemmed

into itself and cannot influence other things without contacting them directly or through a quantitative medium.

Now there are two reasons why such a series of subordinated natural causes must be finite. First of all, an infinite series of physical causes, one placed outside another, would fill an infinity of space.[29] This we have already seen to be impossible if only because finite quantities cannot be strung together to form an infinity.

Second, if our series of physical causes were truly infinite, the causality would take an infinite time to "pass" through it from one member to another into infinity; and such infinite time is not the case.[30] Tilings are done and over in our world, things are made and moved in definite, finite times, and the series of movers in such motions does not stretch to infinity.

b. No *Motion Without a Prime Mover*

Another and "more certain"[31] way of reaching our conclusion is to ask ourselves why we need B to explain C's motion and why, if B is moved in its own turn, we need A to explain B's motions. The answer is an easy one, but it is enlightening. We need B because C is unable to account for the movement in question, and we must go to A and beyond A when we are unable to account for the observed motions. We cannot find in C a reason why C's motion should occur and so we come to B. Not finding in B a reason why C's motion should occur we go to A. And so on. Now if a series of this sort is infinite, we simply multiply to infinity what is incapable of explaining motion. We are seeking to explain motion, and if our series of movers is infinite, we have an infinite series of non-explanations; in seeking the reasons why motion should occur, vve give an infinite multitude of reasons why it should not occur. We do not explain how motion can be by positing an infinite number of reasons why it should not be. It is no explanation of motion merely to multiply without end non-explanations of motion. If there is an actually infinite series of essentially subordinated movers in any motion, such a series, far from accounting for motion, would make it impossible. If then motion occurs, the series of movers in question must be finite, and if it is finite, there is a First or Prime Mover.

According to the first part of our argument, whatever would not be moved by an extrinsic agent would not be moved at all, and there would be no motion. According to the second part of our argument, an infinite series of essentially subordinated movers would provide infinite and hence

complete grounds why motion should not be. If, as experience reveals, there is motion in our world, there is a mover for it because of the principle of causality and there is a Prime Mover for it because of the impossibility of an actually infinite series of movers.

V. THE CONDITIONS OF MOTION

a. *Agent and Patient Are Distinct*

Our proof that nothing is self-moved in a primary way means that the agent and patient in any motion must be distinct from each other. This could be called a condition of motion. For motion is the act of the potential; it requires both act and potency, and these cannot be the same. The agent is necessary to explain the act part of motion and **the patient** the **potential** part. These must be distinct in all motion as one of its very conditions.

b. *Proportion Between Patient and Agent*

The subject must be proportionate to the agent. There must be a potency in the subject for that which the agent can accomplish. Unless the patient has a potency for the term of motion, the agent could not move the patient to achieve such a term. Motion, we have seen, is not a little package of some sort passed from the agent to the patient; indeed nothing really "passes" from the agent to the patient, and yet the patient is passive. Motion is an emergent from the patient rather than something which is put into the patient. There must be a proportionate agent to bring it forth.

c. *Agent Must Be Applied to the Patient*

The agent must be applied to the patient. In the physical world, the agent must be in contact with the patient because the quantity of a physical thing always contains it in its own limits. There is no such thing as the action of one physical thing upon something distant from itself unless the motion takes place through an intervening medium. Action at a distance is impossible for physical things; for the very quantity of anything physical restricts the sensible qualities and motions of the thing within itself. Contact is thus required between the agent and patient **in** any motion, The need of contact between mover and moved is

especially apparent in local motion. This type of motion is the most fundamental, and hence there would be value to using local motion as the basis for our preceding proof. For growth requires alteration and alteration requires contact between agent and patient. The cause of any physical motion must be physically applied to the motion, i.e., the agent must be made to contact the patient as the term of a local motion.

If the agent and patient must be distinct from each other in all motion, it can be reaffirmed that whatever is moved is moved by something other than itself. If mover and moved must be in contact, then an infinite series of physical movers, contiguous with each other, would stretch out to fill an infinity of space. Our conditions of motion thus enable us to strengthen the two propositions in our proof for a Prime Mover.

VI. POSSIBILITY OF AN ETERNAL WORLD

a. Two *Alternatives for Reason*

Our proof for a Prime Mover does not require that the universe be finite in duration.[32] That the world began in time we know by means of revelation, but we could not know by reason alone whether it did so. For all the unaided reason can conclude, the world may have been temporally infinite.

In metaphysics or natural theology it is proved that the world was created, i.e., was produced without a pre-existing subject.[33] From the side of the Maker of the world, God had the power to create it from all eternity, and so from all eternity He could have produced it. From the side of things made, there is no reason why any one creature should have been the first and why some other creature could not have been created before it, and why still another creature could not have preceded, and so on and on. There is no creature whose nature requires that it be the first thing created; creatures, from their side, could have been produced without any one's being first. Even if the world had been created from eternity, it would still have been dependent from eternity on God. Even if it had no temporal beginning, it always had or has a causal beginning.[34]

Did the world have a temporal beginning or did it exist from all eternity? Reason alone cannot say. The question is an open one for reason and is settled only by supernatural revelation which takes us out of purely natural science.

b. *"The More Difficult Hypothesis"*

If reason assumes the alternative that the world had a temporal beginning, it is easy to show that there must be a Prime Mover. "Everything new," as St. Thomas says, "requires an innovating principle."[35] If the world were assumed to have a temporal beginning and there were no Prime Mover to produce it, we would be left with the conclusion that nothing or non-being acted in order to bring our universe into existence. This conclusion is false, for from nothing nothing comes to be: **ex nihilo nihil fit.**

If reason assumes the other alternative that the world had no temporal beginning, it requires a more complex argument to show the need for a Prime Mover. **But if it can be shown that even on supposition of an eternal world a Prime Mover would be necessary, it would be even more compelling to say that a Prime Mover is necessary for a universe temporally finite in origin.**

Aristotle chose the "more difficult" course to prove the existence of a Prime Mover.[36] He assumed an eternal world, and if his proof is valid on this assumption, it would be even stronger on the assumption of a world that began in time.

Even on the assumption of a truly eternal world, Aristotle's argument is most convincing. For as we have seen, the Prime Mover is not a watchmaker God[37] who made the world and gave it an initial push and then went off to leave the universe on its own. In our analysis, the Prime Mover is operating here and now as the First Mover of the nail or the stone or of a blowing leaf or of the ripening of corn. Here and now there is motion, and here and now without a Prime Mover such motion could not be. The moment the hand stops driving a nail, the nail stops being driven, and when the carpenter stops building a house, the house stops being built. The moment a Prime Mover would cease moving anything, at that moment the thing would cease being moved. Just like a projectile that requires a mover not only at its beginning but all throughout its course, the world requires a Prime Mover not only to give it an initial push but for as long as any motion goes on. Here and now in the batting of an eye or the curl of cigarette smoke, there is a First Mover operating or there is no motion.

VII. ATTRIBUTES OF THE PRIME MOVER

a. *The Relevance of This Question*

Our conclusion to the existence of a Prime Mover has rested on two

propositions: Whatever is moved is moved by something other than itself; and in a series of essentially subordinated movers, there is no regression into actual infinity.

There are grounds to question just how much can be known about a Prime Mover within the limits of natural science. The problem of a Prime Mover belongs to the science of nature because the object of our science is to explain mobile being; to achieve this explanation, it is necessary to admit the existence of a Prime Mover.[38] But can we conclude that our Prime Mover is really what Christians call God? Is there only one such Mover? Is such a Mover truly immobile, eternal, simple, personal, provident, the creator of all things outside of Him? Our science of nature cannot answer all of these questions and even questions which it can answer are answered better in metaphysics or natural theology.[39] Our general science, even if it did no more than prove the existence of this non-physical cause which we have called a Prime Mover, would be doing the greatest service it can perform for human reason.

b. St. *Thomas' Position*

St. Thomas affirms that the general science of nature can show that a Prime Mover is eternal, immobile, one or unique, and simple or indivisible. A Prime Mover is eternal because, as an Unmoved Mover, He cannot come to be and pass away.[40] He is immobile because He has no potency[41] that would make Him open to movement from some other and hence more primary cause. He is one because there is a unity to the continuous motion[42] on which our proof has rested. He is without magnitude[43] because, if divisible, He would be dependent on parts and would not be a truly Prime Mover.

Of these five attributes which are discussed in a much more illuminating way in natural theology only two need occupy us further in this introductory text: immobility and indivisibility. As in the case of the other three attributes listed above, the immobile and indivisible character of the Prime Mover is known to us by denying to Him the mobile and divisible qualities we find in material things.

C. *Immobility and Immateriality*

If the Prime Mover were mobile, then He would be open to movement through some other mover or He would be capable of self-motion.

Neither position can be maintained. **A Prime Mover that was open to the influence of another mover would not be a Prime Mover; our series** of movers, it was seen, must end in a First Mover, the Mover of all else, and such a Mover with respect to any other mover must be immobile. But could He move Himself?

The Prime Mover could move Himself only if He had parts where one part moved another, and if one part moved another ad infinitum, our series of movers would not be finite. Hence, there must be something, call it a "part" if you wish or call it a Prime Mover, that is unmoved even by another "part."[44] In short, what distinguishes the Prime Mover from all other movers we know is that He is Unmoved and Immobile. Moreover, if a Prime Mover moved Himself, He would be both a mover and a thing moved. As a thing moved, He would be in potency; as a mover He would be in act. Hence, He would be at the same time and under the same aspect both act and potency; and this would be a contradiction.[45] We have already proved in Chapter XIII that an agent is not the subject of motion. Motion is by the agent, not in it.

A Prime Mover is therefore immobile. He is also indivisible. **For whatever is divisible has magnitude and thus is dependent on its parts and what is dependent in any way is not truly a First.** What is independent has within itself the fullness of reality and it is thus infinite but whatever has magnitude, we have seen, must always be finite.[46] Hence, a First Mover of the World, infinite because it contains all the explanation for motion, cannot have magnitude and be divisible. He must therefore be indivisible. As another approach to the same conclusion, whatever is divisible has parts and is decomposable or destructible, hence mobile; there is no incongruity when that which is divisible should be actually divided and hence destroyed, and if a Prime Mover were a being of this kind, He would surely be mobile. But a Prime Mover cannot be mobile because He is Prime. Hence, He cannot be divisible.

VIII. TOWARD METAPHYSICS AND TOWARD MODERN SCIENCE

a. *Being and Mobile Being Are Separated*

The proof for a Prime Mover opens the door to another realm of being and another realm of human science, namely metaphysics or natural

theology.[47] Previously, for all that unaided reason could know, mobile or material being is all the being that there is; previously, there is no reason to posit any kind of being except physical being.[48] Now, in the proof for a Prime Mover, reason discovers that being is not necessarily mobile[49] and divisible (material); for there is a being, according to our proof, which is immobile and indivisible (immaterial). It is now seen that being is applicable to at least two levels, the mobile or material and the immobile or immaterial. Being does not depend on motion and on matter in order to be and to be understood. A science called metaphysics now becomes possible. Its subject is neither material nor even immaterial being but being as being.[50] But we do not discover that there is such a subject without our proof that there is an immaterial and immobile world and without proof that mobile being, hitherto taken by reason as the only reality, is not truly so. Our proof for a Prime Mover is therefore a precondition of metaphysics or natural theology. Without such a proof, although we could conceive of being that did not require motion and matter in order to be and to be understood, we would not know that being was really distinct from mobile being and hence was really capable of founding an autonomous science. While the science of nature and metaphysics remain distinct disciplines, metaphysics presupposes the science of nature as a material condition.[51]

A Prime Mover, because He is immobile and indivisible, is not strictly a physical cause. Nevertheless, He falls within the scope of natural science because He is necessary in order to explain motion. Let us listen to the words of St. Thomas Aquinas on this point:[52]

> Natural science does not treat of the First Mover as of its subject or as part of its subject, but as the end to which natural science leads. Now the end does not belong to the nature of the thing of which it is the end, but it has a relation to it; as the end of a line is not the line but is related to it. So also the First Mover is of a different nature from natural things, but it is related to them because it moves them. So it falls under the consideration of natural science, not in itself, but in so far as it is a mover.

b. *Context for Modern Science*

Proof for a Prime Mover is thus a limit or term of our science, "the end to which natural science leads." Every important conclusion developed in the foregoing chapters has gone into our proof, and "the end to which natural science leads" has opened a whole new scientific horizon to our gaze. But the mind, following the order -of learning proper to reason itself, is not yet ready to enter upon the difficult territory of

metaphysics. After the general science of nature, like that developed in Aristotle's *Physics,* there must be a penetration of the particular kinds of material being to continue that same science of nature which begins with a study of mobile being in general. In descending to a more detailed knowledge of matter and form, of agent and end, of motion, time, place, and other realities considered in the foregoing pages, science in the modern sense of the term begins and in principle makes more perfect the science of nature that we have developed in its most general and imperfect phases.[53]

The general science of nature is thus important, apart from its other values, in preparing the way for metaphysics and in providing a context for science in the modern sense of the term. Knowing that a Prime Mover is moving the world gives a new dignity to our study of the world's movements.[54] It gives to science in the modern sense of the word an inspiration far greater than any claim usually made for it. If the study of nature does not lead men to God, "the end to which natural science leads," what other motive can be given for the study of science in the modern sense except to know how to make and do things in a practical way?[55] Our general science, on the other hand, can prove the existence of a Prime Mover, because we have avoided that small error in the beginning of a study that can lead to a large one later on. Modern science, as presupposing the truths of general experience that we have tried to analyze, can increase reason's knowledge of what God has made and thus increase our knowledge of God Himself. In speaking of modern scientific discoveries as they bear upon our proof for God's existence, Pope Pius XII has written:

> Genuine philosophers profit from these discoveries in a very special way, because when they take these scientific conquests as the basis for their rational speculations, their conclusions thereby acquire greater certainty, while they are provided with clearer illustrations in the midst of possible shadows, and more convincing assistance in establishing an ever more satisfying response to difficulties and objections.[56]

The proper object of the human intellect is the physical world[57] around us, and hence the more perfectly we can know nature, all other things being equal, the more perfectly we are developing our own natural intelligence. If the First Mover is "the end to which natural science" leads, than every lover of God should be a pursuer of natural science into an ever more perfect form and not merely in its general and introductory dimensions. In these days when we are wondering how to get more and better scientists, it is important, to paraphrase a description made about

St. Thomas, that scientists should be saints, but it is equally necessary to insist that saints should become scientists.

REVIEW QUESTIONS

1. Why does it pertain to the general science of nature to raise the question of the Prime Mover, first, insofar as it is a science of nature and, second, insofar as it is a general science?
2. Explain the two ways of knowing God in this life.
3. Show the relevance of what has been studied so far to the proof for a Prime Mover.
4. Explain what is meant by the principle of causality.
5. Why should the proof for a Prime Mover begin with motion in its strict sense, rather than with change in general?
6. Contrast self-motion in a primary way with motion according to parts.
7. Contrast, with examples, essentially subordinated movers and accidentally subordinated movers.
8. State at least three proofs of the principle of causality which have already been given in this book.
9. Prove that nothing moves itself in a primary way by taking motion in a strict sense of the term and showing how a whole is moved by parts.
10. Explain that the principle of causality as applied to motion is a direct consequence of the divisibility of motion.
11. Is a mover needed only to start a motion?
12. State the objection to the principle of causality that is often taken from Newton's first law.
13. Evaluate this objection.
14. Give and explain two arguments why there cannot be an actually infinite series of essentially subordinated movers.
15. Show why reason alone could not decide the question whether the world began in time.
16. Why was it more logical for Aristotle to assume the world to be eternal in his proof for a Prime Mover?
17. Show why the age of the world has nothing to do with our proof.
18. Explain how there are two different sciences of unaided reason which study the Prime Mover.
19. What attributes of the Prime Mover can be studied in natural science, according to St. Thomas?
20. Prove that the Prime Mover is immobile and immaterial.
21. What is the significance for metaphysics of our physical proof for a Prime Mover?
22. How does St. Thomas explain the relevance of the problem of a Prime Mover to natural science?
23. Explain the significance of the proof for a Prime Mover for science in the modern sense of the term.

PROBLEM

Explain the following passage:

"In this proof, there are two propositions that need to be proved, namely, that everything that is moved is moved by another, and that in movers and things moved one cannot proceed to infinity,

"The first of these propositions Aristotle proves in three ways. The first way is as follows. If something moves itself, it must have within itself the principle of its own motion; otherwise, it is clearly moved by another. Furthermore, it must be primarily moved. This means that it must be moved by reason of itself, and not by reason of a part of itself, as happens when an animal is moved by the motion of its foot. For, in this sense, a whole would not be moved by itself, but a part, and one part would be moved by another. It is also necessary that a self-moving being be divisible and have parts, since, as it is proved in the *Physics,* whatever is moved is divisible.

"On the basis of these suppositions Aristotle argues as follows. That which is held to be moved by itself is primarily moved. For if, while one part was at rest, another part in it were moved, then the whole itself would not be primarily moved; it would be that part in it which is moved while another part is at rest. But nothing that is at rest because something else is at rest is moved by itself; for that being whose rest follows upon the rest of another must have its motion follow upon the motion of another. It is thus not moved by itself. Therefore, that which was posited as being moved by itself is not moved by itself. Consequently, everything that is moved must be moved by another.

"Nor is it an objection to this argument if one might say that, when something is held to move itself, a part of it cannot be at rest; or, again, if one might say that a part is not subject to rest or motion except accidentally, which is the unfounded argument of Avicenna. For, indeed, the force of Aristotle's argument lies in this: if something moved itself primarily and through itself, rather than through its parts, that it is moved cannot depend on another. But the moving of the divisible itself, like its being, depends on its parts; it cannot therefore move itself primarily and through itself. Hence, for the truth of the inferred conclusion it is not necessary to assume as an absolute truth that a part of a being moving itself is at rest. What must rather be true is this conditional proposition: if the part were at rest, the whole would be at rest. Now, this proposition would be true even though its antecedent be impossible. In the same way, the following conditional proposition is true: if man is an ass, he is irrational.

"In the second way, Aristotle proves the proposition by induction. Whatever is moved by accident is not moved by itself, since it is moved upon the motion of another. So, too, as is evident, what is moved by violence is not moved by itself. Nor are those being moved by themselves that are moved by their nature as being moved from within; such is the case with

animals, which evidently are moved by the soul. Nor, again, is this true of those beings, such as heavy and light bodies, which are moved through nature. For such beings are moved by the generating cause and the cause removing impediments. Now, whatever is moved is moved through itself or by accident. If it is moved through itself, then it is moved either violently or by nature; if by nature, then either through itself, as the animal, or not through itself, as heavy and light bodies. Therefore, everything that is moved is moved by another.

"In the third way, Aristotle proves the proposition as follows. Tire same thing cannot be at once in act and in potency with respect to the same thing. But everything that is moved is, as such, in potency. For motion is the act of something that is in potency inasmuch as it is in potency. That which moves, however, is as such in act, for nothing acts except according as it is in act. Therefore, with respect to the same motion, nothing is both mover and moved. Thus, nothing moves itself.

"It is to be noted, however, that Plato, who held that every mover is moved, understood the name *motion* in a wider sense than did Aristotle. For Aristotle understood motion strictly, according as it is the act of what exists in potency inasmuch as it is such. So understood, motion belongs only to divisible bodies, as it is proved in the *Physics*. According to Plato, however, that which moves itself is not a body. Plato understood by motion any given operation, so that to understand and to judge are a kind of motion. Aristotle likewise touches upon this manner of speaking in the De anima. Plato accordingly said that the first mover moves himself because he knows himself and will or loves himself. In a way, this is not opposed to the reasons of Aristotle. There is no difference between reaching a first being that moves himself, as understood by Plato, and reaching a first being that is absolutely unmoved, as understood by Aristotle.

"The second proposition, namely, that there is no procession to infinity among movers and things moved, Aristotle proves in three ways.

"The first is as follows. If among movers and things moved we proceed to infinity, all these infinite beings must be bodies. For whatever is moved is divisible and a body, as is proved in the *Physics*. But every body that moves some thing moved is itself moved while moving it. Therefore, ah these infinites are moved together while one of them is moved. But one of them, being finite, is moved in a finite time. Therefore, all those infinites are moved in a finite time. This, however, is impossible. It is, therefore, impossible that among movers and things moved one can proceed to infinity.

"Furthermore, that it is impossible for the above-mentioned infinites to be moved in a finite time Aristotle proves as follows. Tire mover and the thing moved must exist simultaneously. This Aristotle proves by induction in the various species of motion. But bodies cannot be simultaneous except through continuity or contiguity. Now, since, as has been proved, all the aforementioned movers and things moved are bodies, they must constitute by continuity or contiguity a sort of single mobile. In this way, one infinite is moved in a finite time. This is impossible, as is proved in the Physics.

"The second argument proving the same conclusion is the following. In an ordered series of movers and things moved (this is a series in which one is moved by another according to an order), it is necessarily the fact that, when the first mover is removed or ceases to move, no other mover will move or be moved. For the first mover is the cause of motion for all the others. But, if there are movers and things moved following an order to infinity, there will be no first mover, but all would be as intermediate movers. Therefore, none of the others will be able to be moved, and thus nothing in the world will be moved.

"The third proof comes to the same conclusion, except that, by beginning with the superior, it has a reversed order. It is as follows. That which moves as an instrumental cause cannot move unless there be a principal moving cause. But, if we proceed to infinity among movers and things moved, all movers will be as instrumental causes, because they will be moved movers and there will be nothing as a principal mover. Therefore, nothing will be moved.

"Such, then is the proof of both propositions assumed by Aristotle in the first demonstrative way by which he proved that a first unmoved mover exists."

St. Thomas Aquinas, Summa contra Gentiles[58]

NOTES TO CHAPTER XIX

1. Com. on *the Phys.,* Bk. I, les. 1, n. 4.
2. Sum. cont. Gent., Bk. I, ch. 4.
3. *Phys.,* Bk. VII, ch. 1 (passim); Com. on the *Phys.,* Bk. VII, les. 1, nn. 1759-1780; Summa Theol., I, q. 2, a. 3; On Truth, q. 5, a. 9; Sum. cont. Gent., Bk. I, ch. 13. It should be remarked that the proof for the existence of God as given in the *Physics,* is repeated in the Summa contra Gentiles. The English translation I have used for the principle of causality I owe to J. Owens, whose scholarly studies of the argument from motion are found in his "The Conclusion of the Prima Via," *The Modern Schoolman,* XXX (1952-53), 33-53; 109-121; 203-215.
4. Summa Theol., I, q. 2, a. 3.
5. We have repeatedly treated of what is primary in Chapter VII, p. 132; Chapter XVII, p. 328 ff.; Chapter XVIII, p. 355 ff. Whatever would be primarily self-moved would be moved by itself as a whole — a whole would be moving a whole — and not by reason of its parts. Sum. cont. Gent., Bk. I, ch. 13.
6. Phys., Bk. VIII, ch. 4 (passim); Com. on the Phys., Bk. VIII, les. 11, nn. 2239-2254.
7. *Phys.,* Bk. VII, ch. 1, 242b, 34 ff.; Com. on the *Phys.,* Bk. VII, les. 2, nn. 1781-1797; Summa Theol., I, q. 2, a. 3; Sum. cont. Gent., Bk. I, ch. 13; On Truth, q. 5, a. 9.
8. On Truth, q. 2, a. 10, c; Sum. cont. Gent., Bk. II, ch. 21; Summa Theol., I, q. 46, a. 2, reply 7.
9. Sum. cont. Gent., Bk. II, ch. 38; Com. on *the Phys.,* Bk. VII, les. 2, n. 1784; On the *Power* of God, q. 3, a. 7.
10. Com. on *the Phys.,* Bk. VIII, les. 7, n. 2160; cf. supra, Chapter IX, p. 180.
11. Cf. supra, p. 265 ff.
12. Com. on the Phys., Bk. Ill, les. 5, n. 629.
13. Cajetan, De *Subjecto Philosophiae Naturalis.*
14. This proof is a causal or *propter quid* demonstration based upon the essence of the continuum. The reader is left to formalize this proof. Let it be noted that our proof of the principle of causality is physical and does not, as in metaphysics, extend to all being.

15. *Phys.,* Bk. VII, ch. 1, 242a, 16 ff.; *Com. on the Phys.,* Bk. VII, les. 1, n. 1765; Sum. cont. Gent., Bk. I, ch. 13; Com. on On Gen., Bk. II, les. 10.
16. *Phys.,* Bk. VII, ch. 1, 242a, 20-242b, 20; Com. on the Phys., Bk. VII, les. 1, n. 1766.
17. The foregoing reasoning may be compared to the methods of induction in the British empirical philosophers. Cf., e.g, John Stuart Mill, System of Logic, Bk. Ill, ch. viii (New York, 1930), pp. 255-263.
18. Com. on the Phys., Bk. VII, les. 1, n. 1777.
19. *Ibid.,* Bk. VIII, les. 7, n. 2162.
20. Sum. cont. Gent., Bk. I, ch. 13; Com. on the Phys., Bk. VII, les. 1, n. 1777.
21. *Mathematical* Principles of Natural *Philosophy.*
22. Such is the interpretation of Sir E. Whittaker in Space and Spirit (Chicago, 1948), pp. 50-51.
23. Exposition of the Post. Anal., Bk. II, les. 10; Com. on the *Phys.,* Bk. VI, les. 8, n. 1623.
24. For St. Thomas two theories, cf. Com. on On the Heavens, Bk. II, les. 8; On the Power of God, q. 3, a. 11, reply 5.
25. Cf. Chapter II, p. 33 ff.
26. *Phys.,* Bk. VII, ch. 1, 242b, 19 ff.; Com. on the *Phys.,* Bk. VII, les. 2 (passim); Summa TheoL, I, q. 2, a. 3; Sum. cont. Gent., Bk. I, ch. 13; On *Truth,* q. 5, a. 9.
27. Sum. cont. Gent., Bk. II, ch. 21; Com. on the Phys., Bk. VII, les. 2, n. 1784.
28. Phys., Bk. VII, ch. 1, 242b, 27; Com. on the *Phys.,* Bk. Ill, les. 4, n. 589; Sum. cont. Gent., Bk. I, ch. 13.
29. Sum. cont. Gent., Bk. I, ch. 13.
30. Com. on *the Phys.,* Bk. VII, les. 2, n. 1792.
31. Ibid., Bk. VIII, les. 9, n. 2184.
32. *Ibid.,* les. 1-6 (passim); On the *Eternity of the World,* passim; On the Power of God, q. 3, a. 14, reply 8; Summa TheoL, I, q. 46, a. 1; Sum. cont. Gent., Bk. II, ch. 33-38.
33. Summa TheoL, I, q. 44, a. 1.
34. On the Power of God, q. 3, a. 14.
35. Com. on *the Phys.,* Bk. VIII, les. 1, n. 1991.
36. On the Power of God, q. 3, a. 17.
37. Cf., e.g., *ibid.,* q. 3, a. 7; Coin, on *On Gen.,* Bk. II, les. 10.
38. Com. on *the Trin.,* q. 5, a. 4.
39. Sum. cont. Gent., Bk. I, ch. 13; Com. on On Gen., Bk. I, les. 7.
40. Because on Aristotle's "hypothesis" He moved the world from all eternity. Com. *on the Phys.,* Bk. VIII, les. 12, n. 2274; for other arguments, cf. Summa *TheoL,* I, q. 10, a. 2; Sum. cont. Gent., Bk. I, ch. 15.
41. *Phys.,* Bk. VIII, ch. 9, 266a, 9; Com. on the *Phys.,* Bk. VIII, les. 13 (passim); cf. also Summa TheoL, I, q. 3, a. 3.
42. Phys, Bk. VIII, ch. 10, 267b, 10 ff; Com. on the *Phys.,* Bk. VIII, les. 23, nn. 2523 ff.
43. Phys, Bk. VIII, ch. 10 (passim); Com. on the *Phys.,* Bk. VIII, les. 23 (passim); Summa TheoL, I, q. 3 (passim); Sum. cont. Gent, Bk. I, chs. 17, 18, 20.
44. Com. on the Phys, Bk. VIII, les. 11 (passim); Com. on the *Met.,* Bk. XII, les. 6, n. 2517; Sum. cont. Gent, Bk. I, ch. 13.
45. Sum. conf. Gent, Bk. I, ch. 13.
46. Phys, Bk. VIII, ch. 10, 267b, 20-23; Com. on the Phys, Bk. VIII, les. 23.
47. Cf. W. Baumgaertner, "Metaphysics and the Second Analytics," *The New Scholasticism,* XXIX (1955), 403-426).
48. Com. on the Met, Bk. Ill, les. 6, n. 398; Bk. VI, les. 1, n. 1170; Bk. XI, les. 7, n. 2267.
49. This negative judgment is what St. Thomas means by "separation." Cf. Com. on *the Trin,* q. 5, a. 4.
50. Com. on the *Met.,* Bk. IV, les. 1, nn. 529-531.
51. J. Maritain, The *Philosophy of Nature,* pp. 122-123.
52. Com. on the Trin, q. 5, a. 4. Father G. Klubertanz does not believe that a Prime Mover can be shown to exist in natural science, and he does not believe that such a proof is necessary as a precondition for metaphysics. "It is extremely important to note that just as material being is not a being because it it material, but because it is, so too, an immaterial being (if such there be) is not being because it is immaterial, but because it is. In general, the kind of essence a being has

does not make it a being; whatever its essence, it is a being because and inasmuch as it is.

"Hence it is illusory to attempt to base knowledge of being as being on the demonstrated existence of immaterial things. Either 'is' is freed from its sensible and changing context prior to the proof of the existence of immaterial being and thus is meaningful when we conclude to the existence of such being, or 'is' remains as we first find it immersed in sensibility and change. In the latter case 'is' means 'is sensible, material, changeable,' and to assert that 'An immaterial, immobile thing "is sensible, material and changeable" is a contradiction.' " *The Philosophy of Being* (New York, 1955), p. 43.

By way of evaluating this very critical position, it should be considered that God's existence is known not as an is which is changeable and material but as the cause of such change and such matter. We do not have to await metaphysics in order to employ the principle of causality. Since the effect exists (motion) the cause exists (an agent without motion). It pertains to the science of nature to consider the non-mobile in the same way that a doctor considers the opposite to health or a moral scientist the opposite to the good. The conclusion of our argument is not that "An immaterial, immobile thing is sensible, material and changeable" but that "An agent which is unmoved and unextended is the cause of the motion of extended things." This is no contradiction.

In metaphysics, according to St. Thomas (Com. on *the Trin.,* 5, 4) God is known not as part of the subject but as a principle of the subject; and in a similar way, an Unmoved Mover is known in our science not as a material and mobile subject but as a principle of motion. It pertains to a science to discuss whatever principles, intrinsic and extrinsic, the subject requires.

This long comment concerning an opinion of one of America's finest scholars in philosophy has been made necessary because in the differences between our views the whole problem of the relationships between the sciences and even the very nature of a science itself is at stake.

53. Cf. Chapter V, p. 100.
54. Com. on On Meteor., Bk. IV, les. 1.
55. This was a motive in Bacon, Novum Organon, and Descartes, *Discourse on Method.*
56. From an address of Pope Pius XII to the Pontifical Academy of Sciences on November 22, 1951, translated into English in *Irish Ecclesiastical Record,* 5 ser, LXXVII (1952), 61.
57. On Truth, q. 20, a. 4, reply 1; Com. on the *Eth,* nn. 1122, 1179.
58. Sum. cont. Gent, Bk. I, ch. 13; translated by A. Pegis, On the Truth *of Catholic Faith* (New York, 1955), I, 86-90. Reprinted with permission of Doubleday and Company.

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